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CYTOLOGICAL STUDIES IN INDIAN MOSSES*

I. *Pogonatum microstomum* (R. Br.) Brid., *P. stevensii* Ren. & Card., *Bryum nitens* Hook., and *Physcomitrium pyriforme* (L.) Brid.

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Introduction

The mosses show a high degree of polyploidy in contrast to liverworts which are comparatively stabler, as far as the uniformity of chromosome number and size is concerned. The former also possess a greater capacity to withstand extremes of climate.

Allen (1917) reported the chromosome difference correlated with the sex difference in *Sphærocarpus*. This was followed by extensive researches by various authors on the sex determinants both in liverworts and mosses. Marchal (1911) obtained polyploid series in *Bryum* aposporously. Shimotomai and Koyama (1932) reported the presence of sex chromosomes in *Pogonatum inflexum* Lindb., while Jachimsky (1935) reported the absence of sex chromosomes in diœcious *Pogonatum aloides* (Hedw.) Palis. and *Polytrichum junipericum* Hedw. Kurita (1937) added another two species of *Pogonatum*, i.e., *P. grandifolium* (Lindb.) Jaeger and *P. spinulosum* Mitt. to the list of the species having sex chromosomes. Lowry (1948) published a detailed account of cytotaxonomy of the genus *Mnium*. Vaarama (1949) published an account of meiosis in a species of moss belonging to the family *Grimmiaceæ*, followed by an account of accessory isochromosome in *Dicranum majus* Turn. (Vaarama, 1950). Yano (1951) reported the chromosome number in some Japanese mosses. Vaarama (1953) published the chromosome number of Californian and Finnish mosses. Lowry (1954) reported the chromosome number and relationship

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in the genus *Atrichum* in North America. Steere, Anderson and Bryun (1954) published an account of the chromosome studies in Californian mosses. Recently Steere (1954) published a very comprehensive paper on the chromosome number and behaviour of the arctic mosses reporting the presence of sex chromosome in *Ceratodon heterophyllus* Kindb., *C. purpurens* (H.) Brid., *Sælania glaucescens* (H.) Broth., *Trichodon cyclindericus* (H.) Schp., *Didymodon recurvirostris* (Hedw.) Jenn., *Pohlia cruda* (Hedw.) Lindb., *Bryum argenteum* Hedw. Banerji and Sen (1957) reported the presence of sex chromosomes in *Barbula indica* Brid. Chopra (1957 *a*) reported the sex determinants in *Rhodobryum roseum* (Weis) Limpr. and *Bryum argenteum* Hedw. Chopra (1957 *b*) communicated his observation on the cytological investigations in Lucknow mosses, observing the sex chromosomes in *Mnium* sp. and *Tortula* sp. and Pandé and Chopra (1957) dealt with the cyto-embryology of *Physcomitrellopsis indica* Dix.

The present contribution deals with the cytology of *Pogonatum microstomum* (R. Br.) Brid., *P. stevensii* Ren. and Card., *Bryum nitens* Hook. and *Physcomitrium pyriforme* (L.) Brid.

Material and Method

The specimens of *Pogonatum microstomum* were collected from Mahabaleshwar Western Ghats while *Pogonatum stevensii* was collected from Kodaikanal by Pandé. The material of both the species was fixed in formalin-alcohol. *Bryum nitens* was collected by Mr. N. C. Pathak from Jog Falls (about 2 furlongs away from the rest-house facing the falls). The specimens were fixed in acetic-alcohol (1 : 3). *Physcomitrium pyriforme* was collected from the various localities in Lucknow mainly from the compound of the local I.T. College. The material was fixed in acetic-alcohol (1 : 3).

In the case of the two species of *Pogonatum* the study was confined to paraffin sections cut at 6–8 μ in thickness while *Bryum nitens* and *Physcomitrium pyriforme* were studied from aceto-carmine squash preparations. Both aceto-carmine and safranin-fast green combinations were used though the latter proved superior.

Observations

Pogonatum microstomum (R. Br.) Brid. is diœcious. During the study of the vegetative growth, a number of the meristematic cells, at the apex of the gametophyte, were observed in division stage. In several cells seven chromosomes could be counted at the metaphase. The chromosomes are variable in size and form; four of them being rod-shaped while the remaining three are V-shaped. Among the four rod-shaped chromosomes one is comparatively larger than the other three (Fig. 1).

In the dividing spermatogenic cells seven chromosomes were counted at the metaphase. In this case also the size and form of the chromosomes is variable. Six of the chromosomes are rod-shaped while the seventh is V-shaped. One of the rod-shaped chromosomes

FIGS. 1-13

Figs. 1–4. *Pogonatum microstomum* (R. Br.) Brid. Fig. 1. 7 Chromosomes from the vegetative cell of the gametophyte at metaphase. Fig. 2. 7 Chromosomes at metaphase from the spermatogenic tissue. Figs. 3–4. 7 Bivalents at diakinesis. Figs. 5–8. *Pogonatum stevensii* Ren. & Card. Figs. 5–6. 7 Chromosomes from the spermatogenic tissue including the dot-shaped 'Y' chromosome. Figs. 7–8. 7 Bivalents at diakinesis, one pair H is heteromorphic and precocious in disjunction. Figs. 9–11. *Bryum nitens* Hook. Fig. 9. 10 Chromosomes at metaphase from the spermatogenic cells including one dot-shaped 'Y' chromosome. Figs. 10–11. 10 Bivalents at diakinesis including one heteromorphic pair. Figs. 11–13. *Physcomitrium pyriforme* (L.) Brid. Fig. 11. 9 Chromosomes at metaphase from the spermatogenic tissue. Figs. 12–13. 9 Bivalents at diakinesis.

is smaller than the other five. It lies near the V-shaped chromosome (Fig. 2).

While studying sporogenesis seven bivalents could be counted repeatedly at diakinesis. The bivalents are variable in size; three of them (A, B and C) are larger than the other four. The former show diminution in size in the descending order. A is more or less dumb-bell shaped and B shows cross-chiasma (Figs. 3–4).

Pogonatum stevensii Ren. and Card. is diœcious. During the study of spermatogenesis, a number of spermatogenic cells were seen to be dividing. At metaphase seven chromosomes were counted. The morphology of the chromosomes shows variation. Two of the chromosomes are rod-shaped, four are V-shaped and the seventh is dot-like, 'Y' chromosome. It was observed that the position of the dot-like chromosome is not constant (compare Figs. 5 and 6).

During the study of sporogenesis, seven bivalents were counted at diakinesis and metaphase I in a number of sporocytes. One of the bivalents is positively heteromorphic. In some sporocytes it was observed that the two components show an appreciable difference in size (Fig. 7). The heteromorphic pair is precocious in disjunction (Fig. 8). Among the remaining six autosome pairs A, B and C are larger in the descending order. A is in the form of a thick rod, the other three, however, do not show any appreciable difference. No laggards were found during the process of the formation of diad and tetrad nuclei.

Bryum nitens Hook. is diœcious. Young gametophores, regenerating from the male gametophytes, were squashed and stained in aceto-carmine (details of the process of regeneration will be published elsewhere). At metaphase ten chromosomes could be counted, and nine of these are rod-like while the tenth is the dot-shaped 'Y' chromosome. Among the nine rod-shaped chromosomes two are comparatively larger than the other seven (Fig. 9).

In aceto-carmine capsule squashes ten bivalents could be counted at diakinesis in a number of sporocytes and one of them is clearly heteromorphic, while among the nine autosome pairs A, B, C and D are comparatively larger than the other five pairs which show no appreciable difference. D shows cross chiasma (Fig. 10).

Physcomitrium pyriforme (L.) Brid. is monœcious. In a number of aceto-carmine antheridial squashes nine chromosomes were counted

at metaphase, and among them two are V-shaped while the rest are rod-like (Fig. 11).

In aceto-carmine capsule squashes nine bivalents were counted at diakinesis in a number of sporocytes. One of the pairs, *x*, is appreciably larger than the other eight (Figs. 12–13).

Discussion and Conclusion

Steere (1954, p. 118) remarked that the family *Polytrichaceæ* ranks amongst the most conservative families in terms of stability and uniformity of the chromosome number and size. Our studies of the two species of *Pogonatum* confirm the above statement. As far as the authors are aware polyploid series are not known in this genus. Shimotomai and Kimura (1934–36) and Kurita (1937) and Lowry (1954) reported the polyploid series in the genera *Polytrichum* and *Atrichum* respectively. From the table given below it will be evident that the genus *Pogonatum* is the most stable among the conservative family *Polytrichaceæ*.

Name of the plant	*n*	2 *n*	Author and Year
Genus **Pogonatum**			
P. grandifolium	7 (6+*x*) or 7 (6+*y*)	14 (6″+*xy*)	Kurita (1937)
P. spinulosum ..	7 (6+*x*) or 7 (6+*y*)	14 (6″+*xy*)	,,
P. aloides ..	7	7″	Jachimsky (1935)
P. inflexum ..	7 (6+*x*) or 7 (6+*y*)	14 (6″+*xy*)	Shimotomai & Koyama (1932)
P. alpinum ..	..	7″	Steere (1954)
P. capillare ..	..	7″	,,
* *P. microstomum*	7	14	Pandé & Chopra
* *P. stevensii* ..	7 (6 + *y*)	14 (6″+ *xy*)	,,
Genus **Atrichum**			
A. crispum ..	7	14	Lowry (1954)
A. xanthopelma	7	14	,,
A. angustatum ..	7	14	,,
A. undulatum ..	7	14	,,
A. undulatum ..	14	28	,,
Genus **Polytrichum**			
P. junipericum ..	7	14	Jachimsky (1935)
P. alpestre ..	..	7″	Steere (1954)
P. formosum ..	..	7 (6″ + *xy*)	Shimotomai & Kaimura (1934–36)
P. commune ..	7	14	Jachimsky (1935)

* Based on the present study.

Name of the plant	*n*	2 *n*	Author and Year
Genus **Bryum**			
B. argenteum ..	..	10″	Marchal (1920)
B. argenteum ..	..	10″	Jachimsky (1935)
B. argenteum ..	..	22 (10″+*xy*)	Steere (1954)
B. arcticum ..	..	20″	,,
B. calophyllum	..	40″	,,
B. inclinatum ..	..	30″	,,
B. nitidulum ..	..	20″	,,
B. uliginosum ..	..	10″	,,
Bryum sp. ..	..	50″	,,
B. argenteum ..	10 (9 + *x*)	20 (9″+*xy*)	Chopra (1957)
	10 (9 + *y*)	..	..
* *B. nitens* ..	10 (9 + *y*)	20 (9″+*xy*)	Pandé & Chopra
Funariales			
Genus **Funaria**			
Funaria hygrometrica ..	..	28″	Steere (1954)
F. microstoma Br. & Sch. var. *obtusifolia* Gront.	..	28″	,,
Genus **Physcomitrellopsis**			
Physcomitrellopsis indica ..	..	31″	Pandé & Chopra (1957)
Genus **Physcomitrium**			
* *Physcomitrium pyriforme* ..	9	18	Pandé & Chopra

* Based on the present study.

As will be seen from the accompanying table the chromosomes recorded for the species of *Bryum* is either $n = 10$ or its multiple. Obviously the basic number for this genus is 10. The smallest chromosome number reported so far for the family *Funariaceæ* is $n = 9$.

Summary

The haploid number of chromosomes in *Pogonatum microstomum* (R. Br.) Brid., *P. stevensii* Ren. & Card., *Bryum nitens* Hook. and *Physcomitrium pyriforme* (L.) Brid., is 7, 7, 10 and 9 respectively.

xy Mechanism has been observed in *Pogonatum stevensii* and *Bryum nitens*.

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A SPECIES OF *RICCIA*, *R. ARAVALLIENSIS* PANDÉ *ET* UDAR SP. NOV., FROM MT. ABU, RAJASTHAN, INDIA*

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Introduction

Mount Abu (elev. ca 5,650 ft.), the highest peak at the South-West end of the Aravalli range, is an isolated plateau, which is separated from the main range by the valley of the west Banas river, and arises like a precipitous granite island from the surrounding plains of Marwar in Rajasthan. It is a place of great religious sanctity to the Jains and abounds in some well-known dextrously carved marble temples and shrines of great antiquity (11–13th centuries A.D.). The average annual temperature is about 80° F. and the heat is never intense. The annual rainfall, which is about 68–74 inches, provides the requisite moisture, in favourably sheltered spots, for the growth of the hepatic vegetation which, though not luxurious, is sufficiently interesting. Unfortunately this territory has not received much attention in the past and only eight species of liverworts are known from it and the adjoining areas (Chavan and Mahabale, 1945), *viz.*, *R. discolor* L. *et* L., *R. frostii* Aust., *Plagiochasma appendiculatum* L. *et* L., *Asterella angusta* (St.) Mahabale *et* Bhate, *Conocephalum conicum* (L.) DuMort., *Cyathodium barodæ* Chavan, *Anthoceros himalayensis* Kash. and *Notothylas levieri* Schffn.

Through the courtesy of Dr. K. M. Gupta, Head of the Botany Department, Jaswant College, Jodhpur, Rajasthan, a collection of liverworts from Mt. Abu was placed at the disposal of the authors which on examination revealed the presence of several genera and species greatly extending the number of liverworts so far reported from this territory. These include about half a dozen species of *Riccia*, *viz.*, *R. plana* Taylor, *R. frostii* Aust., *R. crystallina* L., *R. discolor* L. *et* L., *R. billardieri* Mont. *et* N. and *R. gangetica* Ahmad, besides *Plagiochasma appendiculatum* L. *et* L., *Asterella angusta* (St.) Mahabale *et* Bhate, *Marchantia polymorpha* L., *Fossombronia himalayensis* Kash., *Calycularia crispula* Mitt., *Anthoceros* sp., *Phæoceros* sp. and a few others along with the interesting specimens of *Riccia* which differs from the rest of the species of the genus and deserves a new specific rank. A preliminary account of this liverwort has already been communicated by the authors (Pandé and Udar, 1957).

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Description

Riccia aravalliensis Pandé *et* Udar sp. nov.

Monoica, minor, glauco-virens; *frons* ad 3 mm. longa, 1–1·5 mm. lata, antice profunde sulcatis, ad triplo latior quam alata, marginibus crassis; *squamæ* magnæ, dense imbricatæ, marginem frondis haud superantes; *sporæ* fusco-brunneæ, 80–110 μ in maximum diametro, reticulatim-lamellatæ, foveolæ magnæ, 18–35 μ, 3–5 in diametro, lata alatæ, ala ad 6–10 μ.

Monœcious, small, bluish green, cæspitose, occasionally forming rosettes. *Thallus* anteriorly deeply sulcate, posteriorly more or less flat, upto 3 mm. long, 1–1·5 mm. broad, cross-section about 2·5–3 times broader than high, sharply acute; *epidermis* one-layered, cells spherical, thin-walled, hyaline; *scales* large, overlapping, deep violet, not extending beyond the margin, antheridial ostioles prominent; *sporophytes* embedded in the thallus, projecting slightly dorsally, *spore* tetrahedral, dark brown, 80–110 μ in the maximum diameter, reticulate lamellate with only 3–5 large areoles across the outer face, 18–38 μ across, winged, *wing* up to 7 μ wide, pinkish, margin broadly undulate, tri-radiate mark prominent (Figs. 1–9).

Habitat: Mt. Abu, Rajasthan. *Coll.*: K. M. Gupta.

Specimen No. 7000. *Pandé Collection.* (Lucknow University).

Identification

Stephani (1900) divided the 130 species of *Riccia*, recognized by him, into 2 groups:—

1. *Riccia*
2. *Ricciella*

The first group has been further divided into 2 sub-groups:

(α) *Ciliatæ*

(β) *Inermis*

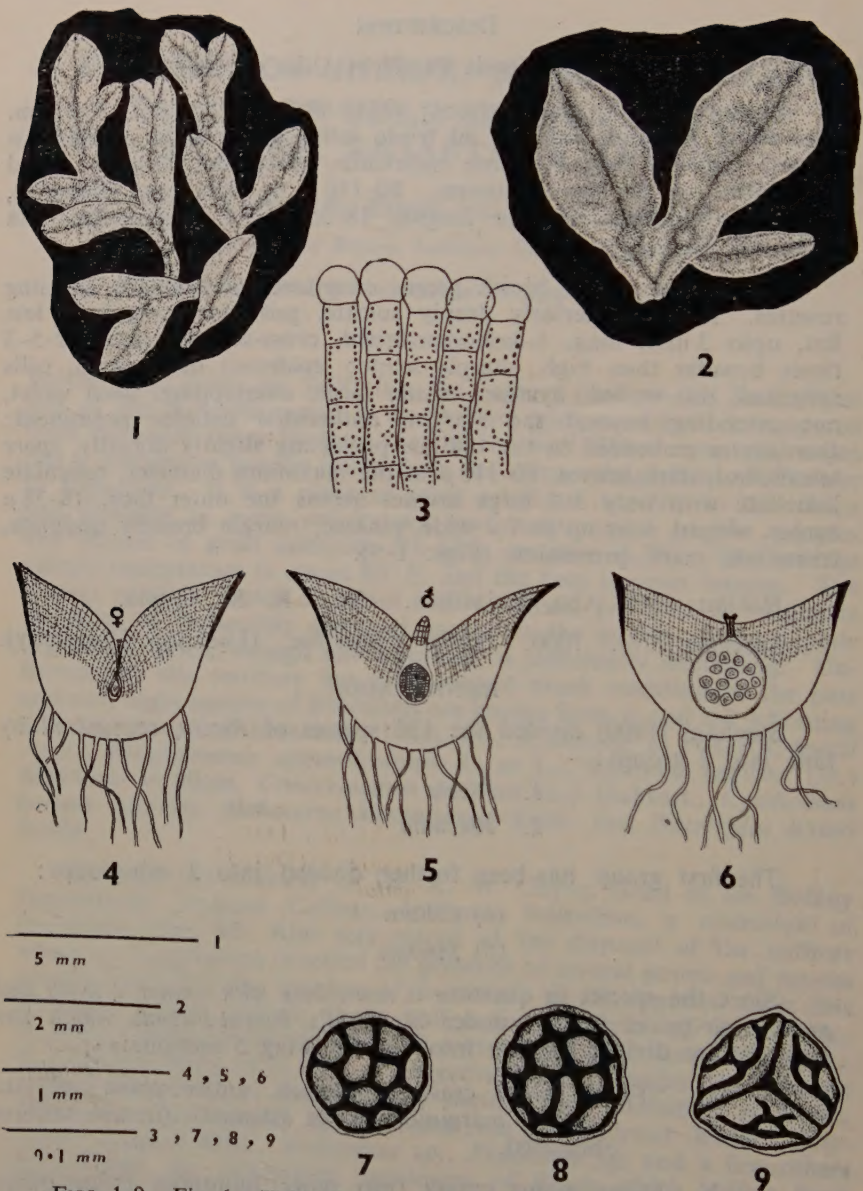
Since the species in question is *non-ciliate with compact thalli and narrow air-spaces* it falls under Stephani's *Riccia-Inermis* which has been further divided by him into the following 5 sections:—

IV. "Frons minus crassa, subtenuis, antice plana vel late concava, marginibus longe attenuatis (in una tantum obtusatis).

V. Frons minus crassa (pro more quintuplo latior quam crassa) antice sulcata, marginibus plus minus attenuatis.

VI. Frons crassa (pro more triplo latior quam crassa) abrupte alata.

VII. Frons crassa (pro more triplo latior quam crassa) marginibus crassis acutis vel obtusis.



FIGS. 1–9. Fig. 1. Habit sketch. Fig. 2. Thalli enlarged. Fig. 3. A part of t.s. of the thallus showing assimilatory filaments and epidermal cells. Figs. 4–6. Cross-sctions of a thallus at the apex, in the middle and at the base respectively. Figs. 7, 8. Two spores (outer face). Fig. 9. A spore (inner faces).

VIII. Frons maxime crassa, pro more diametro parum humilior.

(α) Frons antice *plana* vel *canaliculata* (haud sulcata)
(β) Frons antice sulcata".

The species under consideration has *thick thalli with acute margin* and falls under Section VII above in which the following species have been included by Stephani (1900):—

R. nigrella D C., *R. sorocarpa* Bischoff., *R. insularis* Lev.,* *R. pearsoni* St.,* *R. raddiana* Jack *et* Lev., *R. acuminata* Taylor, *R. austini* St., *R. corcovadensis* St., *R. australis* St.,* *R. porosa* Taylor,* *R. junghuniana* N. et Ldbg., *R. minutissima* St., *R. bifurca* Hoffm. and *R. commutata* Jack.

Of the above 14 species the four marked with an asterisk (*) are diœcious and hence deserve little attention in this connection. The remaining ten resemble the plant under consideration in sexuality but differ in several other important characters. Six of these, *viz.*, *R. raddiana*, *R. acuminata*, *R. austini*, *R. corcovadensis*, *R. junghuniana* and *R. commutata* differ from *R. aravalliensis* in having larger thalli and in the absence of wing in the spore while the remaining four though resemble it, more or less, in the size of the thallus and winged nature of the spore, differ significantly in the size of the spore and the size and number of areoles across the outer face of the spore (see Table I).

In his later publications Stephani (1917–24) added nine more species of *Riccia*, without referring them to the scheme of classification earlier proposed by him. None of these, however, approach *R. aravalliensis*.

Besides the species of *Riccia* included in Stephani's publications (1900; 1917–24) several other species have also been described, *viz.*, *R. trichocarpa* Howe (Howe, 1898); *R. dictyospora* Howe, *R. macallisteri* Howe (Howe, 1917); *R. bistriata* Evans (Evans, 1919); *R. cruciata* Kash. (Kashyap, 1916); *R. pathankotensis* Kash., *R. melanospora* Kash. (Kashyap, 1929); *R. cupulifera* Duthie (Duthie and Garside, 1936); *R. compacta* Garside (Duthie and Garside, 1939); *R. gangetica* Ahmad, *R. orientalis* Ahmad (Ahmad, 1942); *R. pubescens* Hattori (Hattori, 1943); *R. tenella* Jacobs, *R. eldeeniæ* Jacobs (Jacobs, 1949); *R. nipponica* Hattori (Shimizu and Hattori, 1953); *R. kashyapii* Kachroo (Kachroo, 1954) and *R. perssonii* Khan (Khan, 1955). Of the seventeen species of *Riccia* enumerated above six, *viz.*, *R. cruciata*, *R. cupulifera*, *R. compacta*, *R. nipponica*, *R. kashyapii* and *R. perssonii* belong to *Ricciella* section of the genus while six species, *viz.*, *R. trichocarpa*, *R. pathankotensis*, *R. melanospora*, *R. orientalis*, *R. pubescens* and *R. eldeeniæ* are *ciliate*. These twelve species, therefore, differ from the species in question and warrant no consideration. Of the remaining five species *R. dictyospora*, *R. macallisteri* and *R. gangetica* have *spores devoid of wing* and the reticulations are numerous and much smaller thus being very distinct from the species under consideration. The remaining two species, *viz.*, *R. bistriata* and *R. tenella* resemble *R. aravalliensis* in their winged spore but differ markedly in other characters. Thus both *R. bistriata* and *R. tenella* have much larger spores and greater number of reticulations across the spore diameter as well as conspicuously distinct vegetative features.

TABLE I

No.	NAME OF SPECIES	THALLUS SIZE	SPORE				
			Wing	Greatest diameter	Areolæ number	Areolæ diameter	Spore colour
1	*R. nigrella* ..	3 mm.	Present	59 μ	8–10	5 μ	Black
2	*R. sorocarpa* ..	Upto 4 mm.	do.	76 μ	7–10	10 μ	do.
3	*R. raddiana* ..	Upto 12 mm.	Absent	X	X	8 μ	do.
4	*R. acuminata* ..	Upto 2 cm.	do.	X	X	X	X
5	*R. austini* ..	10–12 mm.	do.	82 μ	14	14 μ	X
6	*R. carcovadensis* ..	Upto 15 mm.	do.	110 μ	X	X	X
7	*R. junghuniana* ..	Upto 10 mm.	do.	68 μ	7–8	5 μ	Light brown
8	*R. minutissima* ..	3–4 mm.	Present	76 μ	7–8	8 μ	X
9	*R. bifurca* ..	Upto 5 mm.	do.	68 μ	6–8	8 μ	Dark brown
10	*R. commutata* ..	Upto 6 mm.	Absent	68 μ	6–8	8 μ	do.
11	*R. aravalliensis* ..	Upto 3 mm.	Present	95 μ (80–110 μ)	3–5	28 μ (18–38 μ)	do.

X = Not described.

The species of *Riccia* from Mt. Abu thus differs from all the known species of the genus and is, therefore, referred to as a new species, *Riccia aravalliensis* Pandé *et* Udar.

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STUDIES IN THE ORGANIC ACID METABOLISM OF *ANANAS SATIVA*—I

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The problem of organic acid accumulation in plants as part of their metabolic processes has been the subject of study for many years. In this laboratory work on organic acid metabolism was initiated on *Tamarindus indica* (Seshagiri and Sastry, 1952) and *Rumex* sp. and is now extended to the study of diurnal fluctuations in acidity and the nature of acid accumulation and depletion in *Ananas sativa*. Much of this work was done using standard physiological techniques and the leaves were cultured in darkness in different concentrations of external CO_2 environments.

Materials and Methods

Samples were collected at regular intervals in triplicate from plants of *Ananas sativa* grown in the botanical gardens of the University. The acidity of the leaves was expressed as before (Seshagiri and Sastry, 1952) in terms of titratable acidity. About 1 g. of the plant material was weighed, crushed, the acid extracted by boiling in distilled water and the filtrate titrated against N/50 CO_2-free NaOH using Bromo-thymol blue as indicator (yellow in acid medium turning to blue or bluish green in alkaline medium). The volume of NaOH required to neutralise the acid present in 1 g. of the plant material is expressed as the titratable acid number (T.A.N.).

Identification of Individual Acids by Paper Chromatography

As the values of T.A.N. give only a measure of the total acidity, changes in the different acid constituents in the plant tissue were estimated by adsorption chromatography. The circular paper method using solvents developed by Wiggins and Williams (1952) for the separation of amino acids and sugars was found to be suitable for the separation of the organic acids under study. The solvent mixture of *n*-butanol : formic acid : water (60 : 5 : 35) was used. Bromo-cresol green dissolved in ethanol (alkaline pH) was the spray reagent.

The leaf extract for spotting chromatograms was prepared by digesting a 1 g. leaf sample with 50% alcohol and the extract concentrated and finally made up to volume. The circular paper chromatographic procedure was similar to that of Saifer and Oreskes and of Airan *et al.* (1953) as modified by Ranjan *et al.* (1955) using Whatman No. 1 filter paper. Microdrops of known volume of the plant extract (10 μ l.) were placed by means of a calibrated fine capillary tube, 4 cm. from the centre of the circle in any particular sector. Different reference

solutions of malic, citric, oxalic and tartaric acids were also placed in different sectors to serve as standards. A heavy spot of Sudan III in acetone was placed at the centre of the paper. The dye closely followed the solvent front and R_f values were measured using the leading edge of the dye front as the 1·0 reference point. The dye front was allowed to move at least 10 cm. before stopping the run. The paper was supported on a tripod glass stand kept in a glass chamber well saturated with the solvent. The solvent was taken in a small Petri dish and placed under the filter paper in such a way that the tail-cut hung down at the centre of the dish dipping into the solvent below. After it was allowed to run for a sufficient length of time indicated by the moving dye front, the filter paper was taken out, air-dried and later oven dried at a temperature of 80° C. for about 30 minutes. The paper was then sprayed rapidly and evenly with the spray reagent described above resulting in the production of yellow bands on a greenish blue background.

Measurement of Respiratory Activity

Rate of carbon dioxide evolution was measured by the continuous current method at a temperature of 30° C. $\pm$ 0·1° C. and expressed in terms of mg. CO_2/100 g. fresh weight of the tissue per hour.

Experimental Findings

Diurnal Fluctuations in Titratable Acidity in Different Months

Estimations made at regular intervals of the fluctuations in titratable acidity in mature leaves of *Ananas sativa* during the day in different months are recorded in Table I.

Table I

Diurnal fluctuations in acidity in the leaves of Ananas *in different months*

Months	T.A.N. Values						
	8·00	12·00	16·00	20·00	24·00	4·00	8·00 hrs.
March ..	14·5	1·6	0·78	1·9	6·6	8·9	13·6
April ..	12·2	1·3	0·64	2·0	10·6	7·5	12·0
May ..	11·5	1·1	1·38	2·2	4·3	4·9	11·4
June ..	10·4	2·1	0·80	2·0	7·4	9·2	10·6
July ..	14·2	1·3	1·1	3·0	9·8	12·0	13·9
August ..	16·2	3·1	2·1	5·4	7·5	13·2	16·5

It may be observed from the data that the leaves of *Ananas* exhibit a typical diurnal rhythm in acidity with a high value in the morning declining very fast till noon. Acidity declines still further till the evening when lowest values are noticed. During the night there is a gradual accumulation of these acids more rapidly at first and slowly towards the early hours of the morning. By about 8·00 hours again in the following morning acid content is highest. This diurnal rhythm in acidity is noticed in the six months studied, though the magnitude of the variations naturally differ from month to month.

Chromatograms prepared to study the fluctuations in different periods of the day and night showed that there are two acids in the leaves of *Ananas sativa*—malic and citric of which the former is greater in proportion than the latter and that early in the morning when titratable acidity is highest, both malic and citric are present in high concentrations. As the day advances the malic acid content rapidly declines till 12·00 hours when it is completely absent and does not appear again till 18·00 hours. The citric acid component is more or less steady from morning to noon exhibiting a decline thereafter till 18·00 hours. During the night there is a rapid accumulation of malic acid reaching a high concentration by the next morning. Citric acid, however, starts accumulating only from midnight by which time malic acid accumulates in sufficient quantities.

Culture of Excised Leaves in Darkness

Leaf samples of *Ananas sativa* collected in the evening were illuminated overnight with their cut ends dipped in distilled water to bring the acidity to a minimum. These illuminated leaves were used the next morning for experimentation.

Estimations of titratable acidity, respiratory activity and chromatographic analyses were made at different intervals (Table II).

TABLE II

Drifts in titratable acidity and respiratory activity of leaves of Ananas *cultured in the dark*

Number of hours after start	T.A.N.	CO_2 Output
0	3·4	18·5
3	5·9	15·0
6	6·7	12·5
9	6·9	13·2
12	7·4	33·7
24	6·4	34·2
27	6·8	31·1
30	8·4	30·0
33	8·0	32·0
36	7·8	36·0

Text shows (Table II) that the samples having 3·4 T.A.N. gradually gain acidity during the first 12 hours to attain 7·4 T.A.N. This is followed by a fall during the next 12 hours, the value at the 24th hour being 6·4 T.A.N. This is again followed by a phase of rise and fall in acidity and the value at the end of the 36th hour is 7·8 T.A.N.

The CO_2 output is found to show an inverse relationship to that of acidity and it is evident from the data that the trough values of acidity coincide with the peak values of CO_2 output and *vice versa*.

The chromatograms revealed that the samples start with a low amount of malic and citric acids. With progressive culturing of leaves in the dark, there is progressive dark acidification, the increase in acidity being contributed mainly by the malic acid component, whereas the citric acid component was constant, increasing slightly when the malic acid reaches the optimum concentration.

Changes in Acidity and Respiratory Activity of Ananas *Leaves Collected at Different Times of the Day and Cultured in Darkness*

Leaf samples collected in the morning have a high acidity and those collected in the evening have a low acidity. Fluctuations in acidity and respiratory activity were studied of such leaves, one set collected at the time of high acidity and another set at the time of low acidity and cultured in darkness with their cut ends dipped in distilled water. The data are presented in Table III.

TABLE III

Changes in acidity and respiratory acitivity of leaves of Ananas *cultured in darkness*

No. of hours after start	Leaves collected at 8·00 hours		Leaves collected at 16·00 hours	
	T.A.N.	CO_2 Output	T.A.N.	CO_2 Output
0	11·0	73·38	1·1	33·1
3	11·4	61·8	2·4	30·3
6	10·8	52·0	3·8	31·1
9	10·4	53·7	5·4	25·2
12	11·2	52·4	6·0	19·7
15	10·2	52·4	5·8	16·5
18	11·3	45·0	6·1	17·0
21	10·9	51·2	5·4	17·7
24	9·0	50·0	5·6	23·0

The data show many interesting features. In general, it may be stated that there is acid accumulation on transferring leaves of *Ananas sativa* to darkness, the accumulation being of a very low order in leaves

collected with high acidity and of a very great magnitude in leaves sampled at the low acidity level. Carbon dioxide output in general exhibits a decline in the first 15 to 18 hours in both the high acidity and low acid levels (Table III) after which there is a slight rise. There is one point of difference, however, that the leaves collected at high acidity maintain throughout a higher rate of CO_2 output than leaves collected with a low acidity level throughout the 24-hour period of dark culture.

It is significant to note that peak acid accumulation generally coincides with low CO_2 evolution in both high and low acidity leaves and this is more pronounced in leaves that have an initial low acidity than with those sampled with a high acidity level.

Effect of Different Concentrations of Carbon dioxide Environments

Ananas leaves cultured in different carbon dioxide environments were taken out at 2-hourly intervals and their titratable acidity determined. Chromatograms were also obtained to study the nature of changes in the different acid constituents of the tissues. The data collected are presented in Table IV.

TABLE IV

Effect of different concentrations of Carbon Dioxide on the titratable acidity in Ananas *leaves cultured in darkness*

No. of hours after start	T.A.N. Values in CO_2 Concn.			
	0%	1%	5%	10%
0	2·0	2·2	1·6	1·8
2	2·9	4·0	2·9	3·5
4	3·2	6·1	2·8	6·3
6	4·1	6·8	5·6	7·8
8	4·9	6·0	5·6	4·1
10	6·2	6·5	8·9	9·1
12	5·0	7·0	6·5	7·4

The data collected with respect to leaves cultured in an atmosphere devoid of CO_2 show that there is a steady accumulation of acids during the first 10 hours, the value rising from 2·0 to 6·2. This is followed by a decline in the next 2 hours (Table IV). Chromatograms obtained

with respect to the control samples showed that at the start both malic and citric acids are present in very low concentration. Hourly samples taken during the first 10 hours from leaves kept in darkness show a continuous accumulation of malic acid without any appreciable rise in citric acid content. During this period there is increased T.A.N. In the 12th hour, however, slight decrease is observed in the malic acid constituent while citric acid exhibits a slight increase.

The data obtained also show that culturing the leaves in CO_2-rich environments invariably results in increased acid accumulation in the leaves when compared to the controls. This is also evident from a comparative study of citric and malic acids by chromatograms of control and CO_2-fed leaves.

Leaves of *Ananas* sp. fed with 1% CO_2 concentration show a rapid increase in titratable acidity till the 6th hour (Table IV). During this period the chromatogram obtained shows a marked increase in malic acid while citric acid accumulation is negligible. In the 8th hour there is a decline in titratable acidity and a chromatogram shows a weakening of the bands of both malic and citric acids. In the following period there is observed a further rise in both titratable acidity and in the concentration of both malic and citric acids and at the end of the 12th hour quite a large amount of citric acid accumulates.

Comparison of T.A.N. values obtained for the control and the 1% CO_2 sets show clearly that hour to hour there is increased acid accumulation.

Leaves cultured in environments enriched with 5% CO_2 concentration also exhibit high acid accumulation reaching a high value of 8·9 by the 10th hour (Table IV) in leaves that start with a low acidity of 1·6. Dark deacidification is again observed in the 12th hour even in this high concentration of carbon dioxide.

In leaves fed with 10% CO_2 concentration the rate of accumulation of acid is very much more than in the other sets, starting with a low value of 1·8, by the 4th hour the value is 6·3 (Table IV). It is by the 10th hour that the highest concentration is reached.

The data obtained with respect to titratable acidity and chromatograms prepared of leaf extracts of both control and CO_2-fed leaves show that during acid accumulation, whether it is brought about by darkening the leaf or by increasing the concentration of CO_2 in the environment, it is malic acid that accumulated first and when it reaches a particular concentration it is possibly converted into citric acid. Again, during dark deacidification, as there is a depletion of malic acid, citric acid is possibly converted into some of the intermediate compounds leading to the formation of malic.

Discussion

The data presented indicate that the leaves of *Ananas sativa* exhibit all the features typical of 'crassulacean type' of acid metabolism most important of which is diurnal fluctuation in acidity, *i.e.*, during

the night acid accumulates and during the day there is a depletion in acidity. Though a number of theories have been offered to explain these changes a really satisfactory explanation was not available until Wood and Werkman (1942) established the fact that respiratory or atmospheric CO_2 can serve as a metabolite in the dark. It has been suggested that this CO_2 combines with pyruvic acid or a derivative produced by the phosphorylitic cleavage of carbohydrate, leading to the formation of oxaloacetic acid which is then reduced by $DPNH_2$ in the presence of malic dehydrogenase to yield malic acid. An alternative scheme has also been suggested wherein the oxaloacetic acid after a series of changes through citric and other acids of 'Krebs' cycle may finally yield malic acid. The acid accumulation in the dark in the night is represented by the overall equation of the type:

$$C_6H_{12}O_6 + 2\ CO_2 \rightarrow 2\ C_4H_6O_5$$

as suggested by Thomas (1947).

Experiments conducted in this study by feeding the leaves with increased CO_2 environments have also shown that carbon dioxide is possibly a metabolite utilised for acid synthesis. Records of CO_2 output obtained from leaves kept in the dark also show that, during the periods of acid formation CO_2 evolution is found to be low and *vice versa*.

Another feature of crassulacean metabolism observed is that leaves of *Ananas sativa* begin accumulating acids when they are kept in the dark. This phase of 'dark acidification' is followed by a phase of 'dark deacidification'. In the records made for a sufficiently long period on leaves kept in darkness, a secondary and even a tertiary fall and rise in acidity may also be observed.

Chromatographic analyses of acids in the leaves show that citric and malic acids are the constituent acids in *Ananas* leaves. Diurnal fluctuations in acidity are largely accounted for in terms of changes in only the malic acid constituent. During the night, malic acid accumulates fast and when it reaches an optimum concentration, citric acid begins accumulating. During the daytime it is malic acid that disappears first and then citric acid also begins to decline, possibly giving rise to malic acid through changes suggested in the 'Krebs' cycle.

Summary

Studies made of acid and respiratory changes taking place in *Ananas sativa* suggest that *Ananas* leaves also exhibit typical crassulacean features like diurnal fluctuations in acidity, dark acidification and increase in acidity in environments enriched with CO_2. Malic and citric acids form the constituents of the leaf acids. Fluctuations in acidity are found to be more due to changes in the malic acid constituent than in the citric.

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STUDIES ON THE GERMINATION OF TOBACCO SEED

I. Germination of Some Commercial Varieties of Tobacco*

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During the course of testing some varieties of tobacco considerable variations were encountered in the germinating power among the different varieties. The following experiments were therefore conducted to find out the germinating capacity in the seeds of the principal commercial varieties of tobacco in India under laboratory conditions.

The atmospheric temperature during the nursery season in tobacco-growing areas in coastal Andhra is comparatively high. The range of variation in temperature is 74° to 98° F. (23·3° to 36·4° C.) at Rajahmundry and 75° to 102° F. (23·8° to 38·8° C.) at Guntur during the months of August and September when the seedlings are raised in these areas.

Considerable attention has been given to the study of the influence of temperature on the germination of tobacco seed in other countries. Various authors have reported the optimum temperature for germination between 24° and 32° C. and the maximum between 32° and 40° C. According to Kincaid (1935) the optimum for Florida Cigar Wrapper tobacco seeds is 24° C. and the maximum temperature at which the seeds will germinate is 34° C. This was found to be a rather sharp point, the percentage of germination being 46 at 28° C., 8 at 30° C. and almost nil at higher temperatures. Johnson *et al.* (1930) reported the optimum and maximum temperatures for germination to be 31° C. and 40° C. respectively for Havana seed, the percentage germination being 12 at 40° C. after a prolonged period of incubation.

The high atmospheric temperature conditions in India during the nursery season must doubtless be affecting the germination capacity. For this study the temperatures of 35° C. (95° F.) and 37·8° C. (100° F.) were chosen in order to simulate the natural conditions.

The varieties included were Harrison Special, the principal flue-cured type grown in the Andhra and Mysore States, Chatham, another promising flue-cured type introduced by the Institute, and other commercial types grown in different parts of India, such as Lanka, Cheroot, Chewing, Bidi and Hookah. A few exotic types such as Golden Harvest, Wisconsin and Havana were also included.

Among the varieties tested the seed of 12 varieties were collected in March-April 1952 and 17 varieties in March-April 1953 at Rajah-

* This paper was read at the First Conference of the Tobacco Research Workers in India, held at Bangalore, on 31-1-1957 and 1-2-1957.

mundry from selfed plants. Only the Cheroot variety Vellavazhai of 1953 was a bulk sample from Vedasandur. The seeds after collection were kept in the laboratory in butter paper bags in a cardboard box till the time of experimentation. The seeds collected in 1952 were tested for their germinating capacity in October 1952 and those collected in 1953 were tested in November 1953 and January 1954.

Method

The technique employed consisted of sowing exactly 100 seeds in a dish on a filter-paper placed over moist sterilised sand. Sterilisation of sand was found necessary as otherwise moulds and other fungi often spoiled the tests. Clean washed sand was first passed through a 20-mesh sieve and filled into aluminium dishes of 3·5 cm. diameter and sterilised in an autoclave for half-an-hour at 25 lb. pressure. The sand was then wetted with sterile water and the dishes placed 1 day prior to sowing in an incubator operated by electricity and maintained at the desired temperature. The filter-paper circles (Whatman No. 1) previously sterilised in an oven at 60° C. for 3 hours were placed on the wet sand and the seed sown in the following manner.

For making it easy to sow exactly 100 seeds in each dish and for convenient counting of the germinated ones a rubber stamp was used to impress 100 small squares on the filter-paper using insoluble stencilling ink. The seeds were first spread over a dry glazed porcelain tile so that each seed lay separately. Small pieces of deal wood, pointed like a pencil at one end, were used to transfer the seeds from the tile to the dish by moistening the tip of the pencil, touching a seed at the moistened end and placing the seed which adhered to the pencil on the moistened filter-paper at the required position. By following this method 100 seeds could be placed in about 3 to 4 minutes on the dish in the respective squares. The number of germinated seedlings could now be counted easily and if necessary, their position noted as germination proceeded day by day.

The dishes were watered carefully without dislodging the seeds from their position everyday to keep the sand sufficiently moist for germination to continue. The germination counts were taken once a day at about 24-hour intervals. In this paper, however, only the maximum number of germination attained is reported.

Experimental Results

Ten replicates were tried for each variety and the average germination of the 10 dishes (*i.e.*, 1,000 seeds) calculated as percentage are presented in table below:—

Sl. No.	Variety	1952		1953—54			
		At temperature 95° F.		At temperature 95° F.		At temperature 100° F.	
		Germination percentage	No. of days for attaining constant germination	Germination percentage	No. of days for attaining constant germination	Germination percentage	No. of days for attaining constant germination
1	2	3	4	5	6	7	8
	Cigarette types: Flue-cured—						
1	Harrison Special[1] ..	38·6±3·87	13	36·7±2·75	11	9·0±1·23	17
2	Chatham[2] ..	7·5±2·53	14	7·8±0·74	9	0	10
3	Golden Harvest[3] ..	..	..	32·9±3·63	16	18·2±1·75	16
4	GX 2/33 (Guntur) ..	70·8±2·83	12	60·1±1·89	11	59·9±1·65	13
5	White Burley[4] ..	7·5±3·64	9	..	..	..	..
6	Turkish ..	..	..	85·4±1·41	8	76·4±3·17	12
	Wrapper types—						
7	Havana 142[2] ..	..	..	14·8±3·81	13	0·4±0·31	8
8	15 × 17G ..	67·3±1·53	12	..	..	..	..
9	Variety 301[2] ..	..	..	61·4±3·09	8	4·6±1·93	11
	Filler and Binder type—						
10	Wisconsin[3] ..	..	..	0	13	0	13

	Chewing types—							
11	N. P. 63 (New Pusa)	..	..	..	91·2±1·50	10	79·0±1·90	12
12	N. P. 19 (New Pusa)	..	..	..	71·4±2·73	9	20·5±2·37	11
13	S. 57 (Nipani)	..	78·0±0·73	10	59·4±4·59	12	9·4±2·45	11
14	Dumbara (Ceylon)	..	..	..	2·2±0·23	11	0·5±0·50	13
15	Chewing (Valmonnai)	..	4·2±1·09	14	..	..	..	..
	Hookah type—							
16	Hookah (Ferozepur)	..	..	..	50·8±2·59	10	13·8±2·06	12
	Bidi type—							
17	K. 49 (Gujerat)	..	73·3±4·17	10	..	..	..	..
	Cheroot types—							
18	Cheroot (Vellavazhai)	..	..	..	85·5±1·03	11	77·3±3·04	12
19	Lanka-22 (E. Godavari)	..	91·0±0·41	10	..	..	..	..
20	Lanka-27 (E. Godavari)	..	71·8±1·65	10	82·5±1.23	9	79·9±1·23	10
21	Natu (Bangalore)	..	..	..	82·6±1·06	8	79·3±1·63	12
22	Natu (Guntur)	..	43·0±3·50	14	52·0±1·68	10	14·8±2·59	12
23	Motihari 129 (*rustica*)	..	83·5±0·50	9	..	..	..	..

[1] Goespeed, 1915.
[2] Johnson *et al.*, 1930.
[3] Kincaid, 1935.
[4] Muraoka, 1952.

Discussion

(*a*) *Germinating capacity in the different varieties.*—The percentage of germination varied widely from nil in Wisconsin‡ to over 90 in N.P. 63 and Lanka-22. Similar variations have been observed in various varieties of tobacco seed by Goodspeed (1915), Muraoka (1952) and other workers. An interesting point to be noticed is that germination of the varieties more recently introduced or obtained from temperate regions of America such as H.S., Chatham, Golden Harvest, White Burley, Havana and Wisconsin had considerably lower power of germination (below 40%) compared with typically Indian varieties like Chew ing, Cheroot, Lanka and Natu types which germinated upto 90% in some cases. The Turkish type had also high germinating power. Among the Indian varieties only Valmonnai (a chewing type from Dindigul) and the Dumbara from Ceylon had very low germinating capacity. It will probably not be wrong to conclude that in general the tropical types have better germinating capacity at high temperatures compared to the types introduced from temperate regions though there are a few exceptions. These imported varieties, however, behaved normally after germination and produced normal plants on transplantation under our conditions.

The standard errors of the mean germination percentage given in the table with each estimation vary widely in the different varieties without any relationship with the percentage germination.

Some of the varieties were tested in both the years, *viz.*, H.S., Chatham, GX-2/33, S-57, Lanka-27 and Natu (Guntur). It will be seen from the table that the germinating capacity was at about the same level in H.S. and Chatham in both the years but it was better in 1952 in GX-2/33 and S-57 and better in 1953 in Lanka-27 and Natu (Guntur), although these were collected and stored in a similar manner in both the years. It therefore seems probable that either the germinating capacity in the same variety varies in different years or that similar storage conditions affect the seeds in different ways depending upon some unknown factors in the seed.

(*b*) *Effect of temperature on germination.*—In 1953 the same sample of seeds were tested at the two temperatures of 35° and 37·8° C. Almost invariably except in GX-2/33 and to a certain extent in Lanka-27 and Natu (Bangalore), the germination is lower at the higher temperature showing that the high temperature of 37·8° C. is less congenial for good germination. This is what may be expected owing to the fact that the temperatures at which these tests were made were higher than the optimum temperature of germination of tobacco reported by various authors. However, these tests indicate that the Indian varieties can give as high as 80 to 90% germination even at 37·8° C. Thus, the maximum temperature in case of Indian varieties is higher than what is reported by Kincaid (1935) and may even be higher than what was obtained by Johnson *et al.* (1939). The table also indicates the time

‡ Although the germination is nil in this case, the seeds were viable at least in part, as was evident from fair germination obtained under field conditions.

required for the maximum germination to occur from the time of sowing. In general, it is observed that constant germination is attained in a shorter duration at 95° F. than at 100° F.

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Summary

An easy method of spreading tobacco seeds for conducting germination tests is described.

The germinating capacity of seeds of some commercial tobacco varieties of India at 35° and 37·8° C. are presented. The germinating capacity of the more recently introduced varieties is found to be lower than of varieties acclimatised under Indian conditions for a long time (with some exceptions). The acclimatised Indian varieties can give high germination even at temperatures higher than those reported as optimum in foreign countries.

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TRICHOSPORON CUTANEUM FROM THE FOOT-SKIN OF MAN AND THE EFFECT OF ANTIFUNGAL DRUGS ON IT

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During the course of a survey of ringworm fungi from the outpatients of Gandhi Memorial and Associated Hospitals, Lucknow, in the year 1955, a fungus was isolated from the interdigital space of a man's foot with complaint of pruritus. It differed from the fungi of the dermatophyte group and was found to belong to the genus *Trichosporon* Behrend, 1890. It was considered of interest to study the morphological and physiological characters of this fungus and its pathogenicity to laboratory animals.

Material and Method

The fungus was isolated by the usual method (Ajello, 1951) on Sabouraud's dextrose agar (SDA) plates and freed from bacteria by transfer to SDA slant fortified with pencillin and streptomycin 5 and 50 units/c.c. respectively. Monosporal culture of the fungus was later obtained by the dilution plate method for subsequent studies. Morphological and physiological characters were studied as suggested by Lodder and van-Rij (1952) with certain modifications. The temperature of incubation was 25–27° C. except in the case of malt agar slants which were incubated at room temperature (10–20° C.). 2·5% malt extract (w/v) of *Vitalabs* Extract Malt was used. The growth of fungus in various sugars, ethanol, potassium nitrate and ammonium sulphate was studied both qualitatively and quantitatively (dry weight) (Lilly and Barnett, 1951). 0·05 c.c. of a dilute washed suspension of the fungus in normal saline was used as the inoculum. For dry weight determinations one week old liquid cultures were sterilised by autoclaving at 10 lb. for 10 minutes. These were filtered through previously dried and weighed filter tubes of pyrex glass with fused-in sintered filter discs of medium porosity. The filter tubes with fungus were re-dried at 80–100° C. (constant weight). The weight of the fungus was determined by subtracting the weight of the filter tube from the weight of the filter tube *plus* fungus. The fermentation of sugars was studied in duplicate and the pH and gas production were determined at the end of 10 days.

Morphological and Physiological Characters

Three days old malt extract liquid cultures at 25–27° C. show sediment formation. A few small isolated colonies are also seen adhering to the wall of the flask at the surface of the liquid. No pellicle formation was observed. Microscopic examination revealed pseudo-

mycelium of short and long segments. Arthrospores are united end to end in straight lines and also at angles. They measure 2·8–4·6 μ $\times$ 10·1–27·7 μ. Blastospores are oval and cylindrical to elongated and measure from 4·6–9·2 $\mu \times$ 4·6–18·5 μ. One month old streak culture on malt agar at 10–20° C. shows smooth to partly wrinkled and raised surface growth which is whitish cream in colour. Potato agar slide cultures (3–4 days) at 25–27° C. show good development of mycelial and pseudomycelial formation. Arthrospores are predominantly joined in chains, blastospores are round and oval to cylindrical and occasionally occur in clusters. Few racket-shaped hyphæ were also observed.

The fermentation of sugars by the fungus, its growth with different carbon and nitrogen sources, splitting of arbutin and production of starch-like compounds are presented in Table I. None of the sugars are fermented. The growth of the fungus (on dry weight basis) is very marked with different carbon sources as compared with the control. Ammonium nitrogen is utilized by the fungus while nitrate nitrogen is not assimilated. Splitting of arbutin is weakly positive and no starch-like compounds are produced in agar plate cultures.

Effect of Antifungal Drugs

Dermal application of the fungal suspension was made on the shaved and scarified abdomen of guinea-pigs, rats and mice but no infection could be produced. The effect of undecylenic acid and nycil *in vitro* was, therefore, studied by incorporating these drugs in SDA plates in varying concentrations. Two quinine compounds, hydrochloride and sulphate, were also included in this test. Four concentrations of the drugs were used, 125, 250, 500 and 1000 mg./%. Duplicate plates were poured for each concentration and each plate received a heavy inoculum (0·2 c.c.) of a 24-hour old culture of the fungus. The plates were incubated at 25–27° C. and observed for the presence or absence of fungal colonies after 72 hours. No colonies appeared in the presence of undecylenic acid. 500 mg./% nycil and 1000 mg./% quinine sulphate and hydrochloride completely inhibited the growth of the fungus.

Discussion

Lodder and van-Rij (1952) have recognized 8 species in the genus *Trichosporon* Behrend, 1890. *T. foxi* and *T. krusei* mentioned by Gohar (1948) to have been reported from India and Ceylon by Castellani in 1908, have not been included by Lodder and van-Rij (1952) in their list because the description of these species is not available (Castellani, 1910–19). Out of the 8 species, *T. cutaneum* (de Beurmann, Gougerot et Vaucher) Ota (see Lodder and van-Rij, 1952) has been isolated from skin, fæces, sputum and hair of human beings and also from wood pulp, while *T. infestans* has been isolated only from human skin. The species of *Trichosporon* studied by the author shows close resemblance to *T. cutaneum* in respect of the size and shape of the spores, absence of sugar fermentation, assimilation of sugars, comparatively poor growth in ethanol, non-assimilation of potassium nitrate and weak

TABLE I

Fermentation of sugars, growth of the fungus with different carbon and nitrogen sources, splitting of arbutin and the production of starch-like compounds

Fermentation of sugars					Growth with : Carbon Sources						Nitrogen Sources			Splitting of Arbutin	Production of starch-like compounds in agar plate cultures
Glucose	Galactose	Sucrose	Maltose	Lactose	Glucose	Galactose	Sucrose	Maltose	Lactose	Ethanol	Control	Ammonium sulphate	Potassium nitrate	Control	
*	*	*	*	*	2·700§	2·580	2·392	2·807	2·392	1·367	0·548	2·450	1·717	1·708		
6·5†	8·0	6·5	6·5	6·5	0·100‖	0·090	0·117	0·102	0·092	0·052	0·118	0·085	0·137	0·112	Weakly Positive	Negative
6·0‡	7·5	6·0	6·0	6·0	+++++¶	+++++	++++	+++++	++++	++	+	+	+	+		

* Absence of gas production; † pH of the inoculated tubes after 10 days incubation; ‡ pH of the control; § Dry weight of the fungus in mg. (Average of two); ‖ S.E. of mean; ¶ Growth of the fungus expressed qualitatively.

ability to split arbutin. It, however, differs in minor details from *T. cutaneum* in not being able to form pellicle in liquid malt extract and in having smooth to partly wrinkled colonies on malt agar. It is considered to be a strain of *T. cutaneum* and is being reported for the first time from India.

Summary

A detailed morphological and physiological study of a fungus isolated from the interdigital skin of foot of a man has been made. It has been identified as a strain of *Trichosporon cutaneum*. This is the first record of this species from India. It is non-pathogenic to laboratory animals and is more susceptible to undecylenic acid than to nycil and quinine compounds *in vitro*.

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A COMPARATIVE STUDY OF THE VEGETATION OF SOME AREAS IN JAIPUR DIVISION

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Introduction

The study of desert vegetation has gained considerable importance in recent years due to several reasons. Deserts represent a peculiar life habitat by way of the climatic, edaphic and biotic conditions that prevail in these areas. Plant and animal lives that thrive in these areas are adjusted to the surroundings both morphologically and physiologically which are expressed in their ecological amplitude and their characteristic life forms. It is from this view-point that the desert vegetation has engaged the attention of morphologists and physiologists.

It is often said that the deserts are characterised by scanty vegetation. This is not all true because recent surveys have indicated that even desert areas can support a rich variety of vegetation provided the climatic and biotic conditions are favourable. In several parts of the world the geological studies of the deserts have shown that there have been cycles of climatic changes resulting in desert conditions and these were aggravated by biotic influence. In evaluating the status of vegetation in an area it is therefore necessary to understand the reaction of the vegetation on the existing climate and the biota. Thus the studies on desert vegetation will indicate their exact nature from the ecological point of view.

Studies on the vegetation of the Indian desert have actually been started on a scientific basis only during the present century. The few years of survey indicate that desert conditions are being aggravated and are also extending to the neighbouring parts of the Indian continent. An understanding of the vegetation of the Indian desert from various aspects of its ecology is therefore necessary to combat the expanding evil. In view of the importance of the above aspect afforestation of the desert areas has been undertaken in recent years.

Earlier works on the vegetation of Rajasthan were mostly confined to a survey of the western parts, mainly Jodhpur, Phalodi and Jaiselmer areas. The Eastern Rajasthan, though being the most easily accessible area, seems to have been neglected except for a few sketchy accounts of the trees and shrub species by the forest officers posted in those areas like Jaipur and Alwar.

In comparatively recent years the vegetation of both Western and Eastern Rajasthan is studied by a team of workers from Jodhpur and

Pilani where post-graduate departments in Botany are located. Among the accounts of the vegetation of Western Rajasthan Das and Sarup (1951), Sankhala (1951), Sarup (1951 and 1952), Sarup and Dutta (1954), Sarup and Singh (1953), Sarup and Tandon (1954), Sarup and Vyas (1953), have surveyed the vegetation of Jodhpur division with particular reference to Jodhpur tehsil. Their accounts are both ecological and taxonomic. The vegetation of a part of Bikaner division and its neighbourhood has been described by Joshi (1956).

In a recent publication by the National Institute of Sciences of India, several authors have contributed to the ecology and vegetation of Rajputana desert. An ecological account of a few areas in Rajasthan has been described by Krishnaswamy and Gupta (1952). Nair (1954) has given an account of a study of the vegetation and choice of species in the afforestation of Rajasthan.

Studies on the vegetation of Eastern Rajasthan were started by Mulay and Ratnam (1950), Ramachandran (1950), Ratnam (1951) and they are further taken up by the Pilani School particularly by Ratnam and Joshi (1952), Bakshi (1954), Bakshi and Kapil (1952, 1954), Nair (1956), Nair and Joshi (1955), Nair and Nathawat (1956). Joshi (1956) in recent years has started an intensive ecological study of the sand dune vegetation of Pilani and its neighbourhood.

Jaipur division is one of the important tracts in the Eastern Rajasthan and an ecological survey of this area was undertaken with a view to compare the different ecological zones in this area and also the nature of the vegetation in comparison to the other investigated areas in Rajasthan.

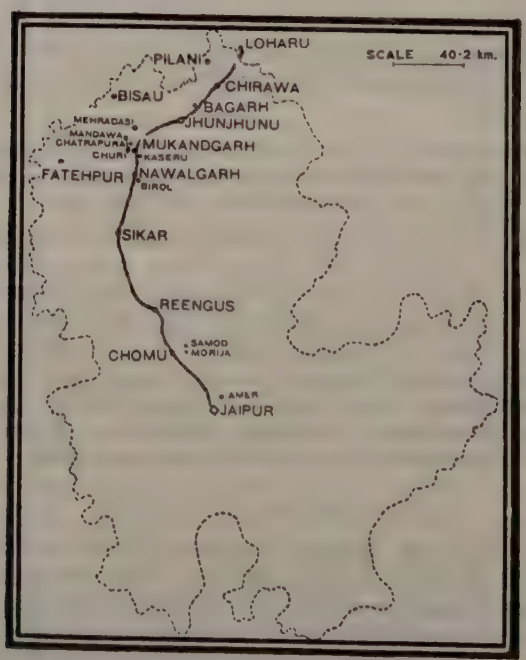
During the course of this investigation the environmental factors were also analyzed in order to correlate the vegetation with it and due importance was given to the nature of the soil also.

The present communication deals with the above aspects of vegetation in this particular area of the desert. The investigated areas include Jaipur proper—where a number of localities like Ghat and Galta Ji in the east, Nullah Gardens and Rawal Ji Ka Bandh in the west, Amer in the north and Gandhi Nagar in south, Chomu Samod situated 45 km. to north of Jaipur on the Western Railway, village Morija and a number of places in Shekhawati which include Pilani, Chirawa, Bagarh (Ratan Shahar), Jhunjhunu, Bisau, Mandawa, Mehradasi, Churi, Chatrapura, Mukandgarh, Kaseru, Birol and Nawalgarh (see Map).

Situation and Topography

Jaipur division lies between longitudes 74·7° and 77·2° E. and latitude 25·8° and 28·5° N. in Rajasthan. This is one of the fertile tracts in Eastern Rajasthan situated towards the south-east of the Aravali ranges. The Shekhawati area in Jaipur division is a little cut off from the rest of the Jaipur division and is situated on the north-west of the Aravali ranges. Thus there are two distinct areas in Jaipur division. The southern and south-eastern regions are mostly plain areas with

Map showing Location of Jaipur Division in Rajasthan with its Neighbouring Areas.



Map showing General Location of the Area Surveyed in Jaipur Division.

very little sand dunes and this area lies adjacent to the semi-desert Gangetic plains in Uttar Pradesh. The north and north-western region comprising the whole of the Shekhawati is characterised by a series of undulating sand dunes interspersed in the plains. This region is in fact a continuation of the more arid zone of the Indian desert and places like Bisau and Fatehpur are boundary villages to Bikaner division in the Western Rajasthan. In both these zones of Jaipur division there are tectonic mountainous chains which are the extensions of the main Aravali ranges.

The vegetation in Jaipur division may thus fall into two distinct categories. In Shekhawati the vegetation is mostly confined to sand dunes and plains and it is subjected to intense arid conditions as available in the Western Rajasthan. On the other hand the vegetation in Jaipur and its neighbourhood is characterised by the absence of intense arid conditions and the plant cover grows in plains and mountainous regions. There are no important rivers or river basins within the mentioned area. However, in Shekhawati the sandy plains are drained by Kantli river and other minor streams which disappear in the sands within the outlines of Jhunjhunu and Sikar Districts. In Jaipur itself there are a number of natural water Bandhs located within the mountain valleys and sometimes form a perennial source of water to the central plains of Jaipur.

Climate

The climate of the area is in general of the semi-arid type with extremes of temperature and low annual rainfall. The meteorological data (Table I) clearly indicate the above aspect. It is however significant that Sikar and other adjacent areas in Shekhawati are characterised by a drier climate and lower annual rainfall than Jaipur and its neighbourhood. These climatic differences result in differences in plant associations which will be shown in succeeding sections. The climate of Jaipur and its neighbourhood is of a moist type and as a consequence the plant species growing in this area are moisture-loving annuals or perennials.

The comparatively semi-arid climate is not very favourable for the luxuriant growth of the vegetation except in the mountain-surrounded valleys where a deciduous forest develops during the rainy season. In the sandy plains, the vegetation shows a close correlation with the unfavourable climate and is represented only by a scrub jungle.

Nature of Soil and Other Environmental Factors

A general survey of the soil samples has been done from different places in different directions at different depths. In Shekhawati area the soils are mostly sandy, brownish or yellow in colour as represented by the soil samples from the sand dunes in the neighbourhood of Pilani. There is very little admixture of clay at deeper depths of the soil. The humus content is also low. The soils have a pH value ranging from 5·00 to 6·00 with one or two exceptions. Carbonates are absent at all depths while nitrates are fairly rich at different levels, but

TABLE I

Monthly Average Records for Rainfall and Temperature of Jaipur, Shekhawati and its Neighbourhood (from 1951 onwards)

Locality	Year	Temperature in Degrees C. and rainfall in mm.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Jaipur ..	1951	Maximum	22·5	26·3	30·7	34·5	40·1	38·5	37·4	31·9	36·1	37·0	30·2	24·9
		Minimum	7·6	8·7	15·8	19·8	24·6	26·0	26·7	24·1	23·1	21·1	14·3	8·6
		Rainfall	1·96	0·0	13·2	1·96	16·4	91·7	78·0	160·8	0·0	0·0	33·0	0·0
	1952	Maximum	24·4	26·9	31·3	38·3	41·6	39·2	34·4	31·3	34·7	35·0	30·1	24·7
		Minimum	9·5	13·2	15·7	22·8	27·3	27·5	26·0	24·1	23·1	18·0	11·8	9·5
		Rainfall	6·6	13·1	2·2	11·7	0·7	33·2	115·0	222·1	4·3	0·7	0·0	0·0
	1953	Maximum	21·3	28·2	35·1	37·6	40·6	39·8	34·6	31·0	33·2	34·5	30·1	28·1
		Minimum	8·5	13·3	18·0	21·3	26·1	27·8	22·3	24·5	23·3	17·6	12·2	10·7
		Rainfall	17·8	0·0	0·0	1·01	0·0	15·2	160·0	223·2	22·8	0·1	0·0	0·0
	1954	Maximum	22·4	25·3	31·4	37·5	42·4	40·5	33·9	33·9	32·2	31·5	29·5	25·1
		Minimum	7·2	12·9	16·4	21·5	26·4	28·5	26·1	24·8	24·2	16·1	12·5	8·4
		Rainfall	4·8	65·3	2·0	0·0	0·0	28·4	245·6	17·7	203·0	26·1	0·25	0·0
	1955	Maximum	22·0	26·5	33·7	35·6	39·6	40·2	35·7	31·2	31·1	30·6	28·6	24·2
		Minimum	9·4	10·2	18·2	18·9	25·6	27·6	26·0	24·6	23·2	17·6	10·6	9·5
		Rainfall	7·6	0·7	0·5	0·2	6·8	86·2	60·9	483·8	101·4	101·2	0·0	0·0

Sikar ..	1951	Maximum	20·8	25·4	30·2	34·7	39·2	38·8	37·8	33·3	36·2	36·7	30·0	25·3
		Minimum	4·0	4·5	13·4	17·6	23·6	25·8	26·8	24·6	23·2	21·4	11·8	8·2
		Rainfall	5·0	0·0	4·8	5·0	16·0	40·6	22·0	172·7	0·0	0·0	33·0	0·0
	1952	Maximum	24·2	26·2	30·8	37·9	41·1	38·6	33·7	31·8	35·0	34·7	29·9	24·8
		Minimum	7·6	14·5	17·2	22·5	25·5	27·4	25·5	24·0	22·2	15·9	8·5	5·1
		Rainfall	0·0	9·1	2·3	9·4	2·5	53·6	151·7	140·7	2·1	0·0	0·0	0·2
	1953	Maximum	21·1	28·1	34·6	36·8	39·6	38·8	34·6	31·9	34·7	34·0	29·6	27·6
		Minimum	6·2	9·2	14·7	19·2	25·4	28·1	26·6	24·4	23·0	15·0	8·8	6·6
		Rainfall	22·7	0·0	0·0	7·6	7·8	81·3	58·5	274·3	86·4	0·0	0·0	2·54
	1954	Maximum	21·8	24·6	30·8	36·8	40·0	39·2	34·2	34·4	31·0	31·4	28·9	24·7
		Minimum	5·2	10·7	12·5	18·8	24·6	27·2	25·8	25·1	24·3	14·9	10·3	5·4
		Rainfall	6·3	20·3	7·6	0·0	0·0	5·1	111·7	26·4	68·6	22·7	0·0	0·0
	1955	Maximum	21·6	26·1	33·1	34·9	38·4	39·2	36·1	32·7	32·1	31·0	Not recorded	
		Minimum	6·3	7·2	15·0	15·3	22·4	28·1	27·2	24·8	23·0	16·4	do.	
		Rainfall	1·8	0·0	0·0	0·0	5·1	109·2	76·2	210·8	116·8	99·0	do.	

more so at a depth of 30 cm. The soils are not base deficient as shown by the ammonium thiocyanate test (Table II).

In Jaipur region the soil samples towards the southern region, *i.e.*, the Gandhi Nagar area, are in close comparison with the soil samples of Shekhawati area. This is mainly because of the sandy nature of the soil in this part of Jaipur. In other directions the soil ranges from sandy to gravel and gritty types with varying degrees of humus content. In the gritty soils the humus content is more while in mixtures of sandy and gravel regions the humus content is comparatively less. The pH value ranges from 6·00 to 8·50 in different directions while in certain localities in the north, *i.e.*, Amer hill area, the pH value might fall to 5·00 occasionally. On the whole the soil samples in the Jaipur region are alkaline. Soil samples are also fairly rich in carbonates at different depths which show that they are not leached away from the soil due to the colloidal nature of the soils. Nitrates are also fairly rich at different depths in all directions. The soils are also not base deficient.

A comparative study of the soils thus shows that there is a marked difference with regard to their pH value and carbonate contents. The sandy soils have a pH value on the acidic side with no carbonates, while the gritty and plain soils have a pH value on the alkaline side with fairly rich amount of carbonates (Table II).

Some cultivated fields in Shekhawati and Jaipur areas were also examined to understand the nature of the soil. In view of the uniformity of the manure conditions and other agricultural practices it is seen that there is not much difference in soils of cultivated fields from the two different areas. The pH value is on the alkaline side in the soil of these cultivated fields. Nitrates are in considerable quantities and the carbonates also fairly rich. The soils are not base deficient (Table II).

The Chomu Samod and village Morija area are typical of central plain areas of Eastern Rajasthan and an analysis of the soil samples in these areas shows the following features. The surface soils are sandy while there is considerable loam at deeper layers. The pH value ranges between 7·00 and 8·00. The nitrates and carbonates are sparingly present, while the soils are not base deficient (Table II).

Biotic Factors

The main biotic agents which affect the development of vegetation of the area are the grazing cattle, sheep and man. In addition to these, wild rabbits, deer and rodents cause considerable damage to the developing vegetation. The locusts and other insects which invade the desert tracts of Rajasthan are another source of considerable disturbance for the vegetation. Many plants growing within the areas are attacked by pathogenic fungi and termites which definitely prove harmful for the growing vegetation. The soil micro-organisms are, however, not noted, but it is likely that their role is insignificant in the area due to the fact that the desert soils are not suitable for their activities.

Vegetation in Different Areas

The Shekhawati area is characterised by typical arid conditions of the western region of the Indian desert. Consequently there is a considerable resemblance of the vegetation of this area to that of west. There is, however, disparity of the dominant plant associations in different regions of the Shekhawati area. In typical sand dune regions, as exemplified at Pilani and its surroundings, the most characteristic species include *Leptadenia pyrotechnica*, *Calotropis procera*, *Crotalaria burhia*, *Euphorbia clarkeana*, *Bærhavia diffusa*, *Aerva tomentosa*, *Mollugo cerviana* and *Mollugo nudicaulis*. The tree species include *Balanites ægyptiaca*, *Gymnosporia spinosa*, *Prosopis spicigera* and *Capparis decidua*. Growing as a climber over these species are *Ephedra foliata* var. *ciliata* and a number of cucurbitaceous climbers which are very common. The sand dune areas thus support very little vegetation and the very species that grow within these regions are adapted to the extreme conditions of environment to which they are subjected.

The sand dunes in other areas of Shekhawati like Bisau and Mehradasi support characteristic associations of *Calligonum polygonoides* and *Zizyphus rugosa* and are seen extending over several miles in these areas. In the rainy season and extending late in the winter these perennials are supplemented by a number of plant species which include grasses, and plants like *Tephrosia purpurea*, *Crotalaria burhia*, *Leptadenia pyrotechnica*, *Bærhavia diffusa*, *Mollugo cerviana*, *Mollugo nudicaulis*, *Trianthema decandra*, *Gisekia pharnaceoides*, *Fagonia cretica*, *Tribulus terrestris* and *Borreria hispida*.

On the way to Jhunjhunu, the Chirawa-Bagarh area is characterised by extensive association of *Salvadora persica*. Under the shade of these trees a number of plants grow during the rainy season forming ephemeral mixed ground flora. They include *Achyranthes aspera*, *Peristrophe bicalyculata*, *Justicia procumbens*, *Commelina benghalensis*, *Sida cordifolia*, *Abutilon indicum*. In addition, cucurbitaceous climbers are abundant over the *Salvadora*. Towards Churi, Chatrapura and Mukandgarh, there are large extensive association of *Balanites ægyptiaca*, while in the Navalgarh area *Leptadenia* is found to form the dominant association in certain parts.

The central plain area as shown by Chomu Samod and village Morija does not much differ from the sandy areas of Shekhawati. The dominant plant association in this area is *Prosopis-Zizyphus* complemented by *Leptadenia pyrotechnica*, *Calotropis procera*, *Crotalaria burhia*, *Aerva tomentosa* and others. Other associations are of *Capparis-Acacia* and *Clerodendrum-Euphorbia*.

The Jaipur area is characterised by hills all around with sandy plains towards the south. The sandy areas show almost similar vegetation to that of Shekhawati region, the most dominant plant association being that of *Capparis* and *Gymnosporia*. At some places towards the hills *Acacia* and *Zizyphus* are dominant plants. The absence of *Prosopis* from this region is of considerable interest. The low shrub

TABLE II

Characters of the Soil Samples in Shekhawati, Jaipur and its Neighbourhood Areas from Different Directions and at Different Depths

Locality	Direction	No. of Soil Samples	Depth in cm. at which Soil Samples were taken	Colour of Soil	Texture	Carbonate Content	Nitrate Content	Chloride Content	Reductivity	pH Value
PILANI and its neighbourhood (only sandy areas were studied)	East	A	7·5	Brown	Sandy	–	+++	+	+	5·0
		B	15·0	do.	do.	–	++	+	+	6·0
		C	22·5	do.	do.	–	++	+	+	5·0
		D	30·0	do.	do.	–	+++	+	–	7·5
	West	A	7·5	do.	do.	–	+	+	+	7·5
		B	15·0	do.	do.	–	+++	+	+	5·5
		C	22·5	do.	do.	–	++	+	–	5·5
		D	30·0	do.	do.	–	++++	+	–	5·0
	North	A	7·5	do.	do.	–	++	+	+	4·0
		B	15·0	do.	do.	–	+	+	–	5·5
		C	22·5	do.	do.	–	++	+	+	5·5
		D	30·0	do.	do.	–	++++	+	+	5·5
	South	A	7·5	do.	do.	–	++	+	+	5·5
		B	15·0	do.	do.	–	++++	+	+	5·5
		C	22·5	do.	do.	–	+++	+	+	5·0
		D	30·0	do.	do.	–	++	+	+	5·5
CHOMU SAMAD (includes village Morija also)		1	7·5	Brownish	Sandy	++	+	++	–	8·0
		2	15·0	do.	do.	+	++	++	–	7·5
		3	22·5	do.	do.	+	+	++	–	7·5
		4	30·0	do.	do.	+	++	++	–	7·5
JAIPUR (Ghat area) ..	East	A	7·5	Brownish Black	Sandy	+	++++	+++	–	8·0
		B	15·0	do.	do.	+	++++	+++	+	8·0
		C	22·5	do.	do.	++	+	+++	–	8·0
		D	30·0	do.	do.	++	++	+++	–	8·0

JAIPUR (Gultaji Hill area)	East	1	7·5	Black	Rocky	+	++++	+	+	8·0
		2	15·0	do.	do.	++	++	+	–	8·0
		3	22·5	do.	do.	–	++++	+	–	8·0
		4	30·0	do.	do.	++	++++	+	–	8·0
JAIPUR (Ravalji ka Bandh area)	West	A	7·5	Brownish and Black	Sandy	++++	+	+	–	7·5
		B	15·0	do.	do.	++++	++	+	–	7·5
		C	22·5	do.	do.	++++	++	+	–	7·5
		D	30·0	do.	do.	++++	+++	+	–	8·5
JAIPUR (Nullah Gardens)	West	A	7·5	do.	do.	+++	++	+	–	6·5
		B	15·0	do.	do.	+++	++	+	–	6·0
		C	22·5	do.	do.	+++	+++	+	–	6·5
		D	30·0	do	do.	+++	++	+	–	7·5
JAIPUR (Soil taken from the cultivated fields near about Rawalji ka Bandh)	West	A	7·5	Brown	Sandy	+++	++	+	–	7·5
		B	15·0	do.	do.	+++	+++	+	–	7·5
		C	22·5	do.	do.	+++	+++	+	–	7·5
		D	30·0	do.	do.	+++	+++	+	–	7·5
JAIPUR (Soil samples collected on way to Amer)	North	1	7·5	Brownish Black	Rocky	++++	++++	+	–	8·5
		2	15·0	do.	do.	+	++	+	–	6·0
		3	22·5	do.	do.	+	++	+	–	6·5
		4	30·0	do.	do.	++	+++	+	+	6·5
		5	37·5	do.	do.	+++	++++	+	–	6·0
JAIPUR (Amer hill area)	North	1	7·5	Black	Rocky	+	++	+	+	6·5
		2	15·0	do.	do.	++	++++	+	–	7·0
		3	22·5	do.	do.	+++	+++	+	–	8·0
		4	30·0	do.	do.	+++	++++	+	–	5·0
		5	37·5	do.	do.	+++	++++	+	–	5·5
JAIPUR (Soil samples collected from cultivated fields on way to Amer)		A	7·5	Black	Sandy	+	++	+	–	6·0
		B	15·0	do.	do.	++	++++	+	–	7·0
		C	22·5	do.	do.	+	++++	+	–	6·0
		D	30·0	do.	do.	++	+++	+	–	6·0
JAIPUR (Gandhi Nagar area)	South	A	7·5	Brown	Sandy	–	+	+	–	5·5
		B	15·0	do.	do.	–	++	+	–	5·5
		C	22·5	do.	do.	–	+++	+	–	6·0
		D	30·0	do.	do.	–	++++	+	–	6·0

species available in this area are *Tephrosia purpurea, Crotalaria burhia, Leptadenia pyrotechnica* with a number of rainy season annuals characteristic of the Shekhawati area.

The hill vegetation is characterised by the plants like *Gymnosporia, Acacia*, giant *Euphorbia, Justicia adhatoda* and sometimes *Zizyphus* and *Tecoma*. There are a number of plant species extending to the winter and they include *Tephrosia purpurea, Crotalaria burhia, Leptadenia pyrotechnica, Bœrhavia diffusa, Euphorbia hirta* and *Sida rhombifolia*. During the rainy season there is a considerable herbaceous cover over the mountains and a large number of species grow in the area. The number and composition of species show considerable resemblance to the hilly tracts of Shekhawati surveyed by Ratnam (1951).

Plant Associations

The following plant associations have been recognised during the course of the study:—

Shekhawati Area

I. *Capparis-Gymnosporia* Association

1.	*Capparis decidua* (Forsk.) Pax.	*d.*
2.	*Gymnosporia spinosa* (Forsk.) Fiori.	*co.d.*
3.	*Tephrosia purpurea* Pers.	*a.*
4.	*Ephedra foliata* var. *ciliata* Boiss.	*c.*
5.	*Mollugo nudicaulis* Lamk.	*c.*
6.	*Euphorbia clarkeana* Hk.f.	*c.*
7.	*Crotalaria burhia* Ham.	*c.*
8.	*Bœrhavia diffusa* Linn.	*c.*
9.	*Coccinia indica* Wt. et. Arn.	*c.*
10.	*Calotropis procera* Br.	*c.*
11.	*Leptadenia pyrotechnica* (Forsk.) Decne.	*a.*
12.	*Eragrostis stenophylla* Hochst.	*a.*
13.	*Eragrostis viscosa* Trin.	*a.*
14.	*Trianthema monogyna* Linn.	*r.*
15.	*Prosopis spicigera* L.	*r.*

II. *Salvadora* Association

1.	*Salvadora persica* Linn.	*d.*
2.	*Achyranthes aspera* Linn.	*c.*
3.	*Peristrophe bicalyculata* Nees.	*c.*
4.	*Justicia procumbens* L.	*c.*
5.	*Commelina benghalensis* L.	*c.*
6.	*Sida cordifolia* L.	*a.*
7.	*Abutilon indicum* Sweet.	*a.*
8.	*Coccinia indica* Wt. et. Arn.	*a.*
9.	*Eragrostis tremula* Hochst.	*c.*
10.	*Cenchrus setigerus* Vahl.	*c.*

III. *Prosopis-Capparis* Association

1.	*Prosopis spicigera* L.	*d.*
2.	*Capparis decidua* (Forsk.) Pax.	*d.*

3.	*Abutilon indicum* Sweet.	.. *r.*
4.	*Achyranthes aspera* L.	.. *r.*
5.	*Zizyphus rugosa* Lamk.	.. *r.*
6.	*Aerva tomentosa* Forsk.	.. *c.*
7.	*Cenchrus setigerus* Vahl.	.. *a.*
8.	*Dactyloctenium ægyptium* Beauv.	.. *a.*
9.	*Andropogon annulatus* Forsk.	.. *c.*
10.	*Bærhavia diffusa* L.	.. *c.*
11.	*Tephrosia purpurea* Pers.	.. *c.*
12.	*Ephedra foliata* var. *ciliata* Boiss.	.. *c.*
13.	*Sida cordifolia* L.	.. *r.*
14.	*Corchorus tridens* L.	.. *r.*
15.	*Physalis minima* L.	.. *r.*
16.	*Tribulus terrestris* L.	.. *r.*
17.	*Euphorbia hirta* L.	.. *c.*
18.	*Argemone mexicana* Linn.	.. *c.*

IV. *Calligonum-Zizyphus* Association

1.	*Calligonum polygonoides* Linn.	.. *d.*
2.	*Zizyphus rugosa* Lamk.	.. *co.d.*
3.	*Tephrosia purpurea* Pers.	.. *c.*
4.	*Cenchrus setigerus* Vahl.	.. *a.*
5.	*Cenchrus ciliaris* L.	.. *a.*
6.	*Prosopis spicigera* L.	.. *r.*
7.	*Corchorus æstuans* Linn.	.. *c.*
8.	*Aerva tomentosa* Forsk.	.. *c.*

V. *Acacia-Calligonum* Association

1.	*Acacia leucophlæa* Willd.	.. *d.*
2.	*Calligonum polygonoides* L.	.. *co.d.*
3.	*Achyranthes aspera* L.	.. *a.*
4.	*Pupalia lappaceæ* (Linn.) Juss.	.. *c.*
5.	*Tribulus terrestris* L.	.. *c.*
6.	*Eragrostis minor* Host.	.. *a.*
7.	*Eragrostis tennella* R. & S.	.. *c.*

VI. *Balanites-Zizyphus* Association

1.	*Balanites ægyptiaca* L.	.. *d.*
2.	*Zizyphus rugosa* Lamk.	.. *co.d.*
3.	*Tephrosia purpurea* Pers.	.. *r.*
4.	*Sida cordifolia* L.	.. *d.*
5.	*Cenchrus setigerus* Vahl.	.. *c.*
6.	*Tribulus terrestris* L.	.. *a.*
7.	*Eragrostis viscosa* Trin.	.. *a.*
8.	*Commelina benghalensis* Linn.	*c.*

CHOMU-SAMOD AREA (includes village Morija also)

I. *Prosopis-Zizyphus* Association

1.	*Prosopis spicigera* Linn.	.. *d.*
2.	*Zizyphus nummularia* Wt. et. Arn.	.. *co.d.*

3.	*Aerva tomentosa* Forsk.	..	*c.*
4.	*Leptadenia pyrotechnica* (Forsk.) Decn.	..	*c.*
5.	*Sida cordifolia* Linn.	..	*c.*
6.	*Bærhavia diffusa* Linn.	..	*c.*
7.	*Justicia procumbens* Linn.	..	*c.*
8.	*Tephrosia purpurea* Pers.	..	*a.*
9.	*Abutilon indicum* Sweet.	..	*c.*
10.	*Indigofera argentea* Linn.	..	*c.*
11.	*Cenchrus setigerus* Vahl.	..	*c.*
12.	*Eragrostis tremula* Hochst.	..	*c.*
13.	*Calotropis procera* Br.	..	*r.*
14.	*Tragus biflorus* Schult.	..	*c.*

II. *Capparis-Acacia* Association

1.	*Capparis decidua* (Forsk.) Pax.	..	*d.*
2.	*Acacia arabica* Willd.	..	*co.d.*
3.	*Gymnosporia spinosa* (Forsk.) Fiori.	..	*a.*
4.	*Zizyphus jujuba* Lamk.	..	*r.*
5.	*Cryptostegia grandiflora* Br.	..	*r.*
6.	*Portulaca quadrifida* Linn.	..	*c.*
7.	*Saccharum munja* Roxb.	..	*c.*
8.	*Justicia adhatoda* Linn.	..	*r.*
9.	*Eragrostis tremula* Hochst.	..	*c.*
10.	*Borreria hispida* (L.) Schum.	..	*c.*
11.	*Achyranthes aspera* Linn.	..	*c.*
12.	*Tridax procumbens* Linn.	..	*c.*
13.	*Crotalaria burhia* Ham.	..	*c.*
14.	*Argemone mexicana* Linn.	..	*c.*
15.	*Euphorbia microphylla* Linn.	..	*c.*
16.	*Euphorbia hirta* Linn.	..	*c.*

III. *Clerodendrum-Euphorbia* Association

1.	*Clerodendrum phlomidis* Linn.	..	*d.*
2.	*Euphorbia royleana* Bioss.	..	*co.d.*
3.	*Justicia adhatoda* Linn.	..	*c.*
4.	*Tridax procumbens* Linn.	..	*c.*
5.	*Evolvulus alsinoides* Linn.	..	*c.*
6.	*Artemisia scoparia* Waldst. & Kit.	..	*c.*
7.	*Anogeissus pendula* Edgew.	..	*c.*
8.	*Borreria hispida* (L.) Schum.	..	*r.*
9.	*Pupalia lappaceæ* (Linn.) Juss.	..	*c.*
10.	*Amarantus viridis* Linn.	..	*c.*
11.	*Indigofera argentea* Linn.	..	*c.*

JAIPUR AREA

I. *Gymnosporia-Capparis* Association

1.	*Gymnosporia spinosa* (Forsk.) Fiori.	..	*d.*
2.	*Capparis decidua* (Forsk.) Pax.	..	*co.d.*
3.	*Justicia adhatoda* Linn.	..	*co.d.*

4.	*Leptadenia pyrotechnica* (Forsk.) Decne. ..	*c.*
5.	*Calotropis procera* Br. ..	*c.*
6.	*Euphorbia hirta* Linn. ..	*c.*
7.	*Heliotropium myriofilum* Wall. ..	*c.*
8.	*Portulaca oleraceæ* Linn. ..	*c.*
9.	*Achyranthes aspera* Linn. ..	*c.*
10.	*Abutilon indicum* Sweet. ..	*c.*
11.	*Sida cordifolia* Linn. ..	*c.*
12.	*Indigofera linifolia* Retz. ..	*c.*
13.	*Cenchrus setigerus* Vahl. ..	*c.*
14.	*Eragrostis tremula* Hochst. ..	*c.*

II. *Acacia-Prosopis* Association

1.	*Acacia arabica* Willd. ..	*d.*
2.	*Prosopis spicigera* Linn. ..	*co.d.*
3.	*Zizyphus rotundifolia* Lamk. ..	*c.*
4.	*Crotalaria burhia* Ham. ..	*c.*
5.	*Justicia adhatoda* Linn. ..	*c.*
6.	*Sida cordifolia* Linn. ..	*c.*
7.	*Tephrosia purpurea* Pers. ..	*a.*
8.	*Tridax procumbens* Linn. ..	*c.*
9.	*Amarantus spinosus* Linn. ..	*c.*
10.	*Pupalia lappacea* (Linn.) Juss. ..	*c.*

III. *Anogeissus-Boswellia* Association

1.	*Anogeissus pendula* Edgew. ..	*d.*
2.	*Boswellia serrata* Roxb. ..	*co.d.*
3.	*Holoptelea integrifolia* Planch. ..	*a.*
4.	*Acacia senegal* Willd. ..	*a.*
5.	*Euphorbia royleana* Boiss. ..	*a.*
6.	*Justicia adhatoda* Linn. ..	*a.*
7.	*Tephrosia purpurea* Pers. ..	*c.*
8.	*Justicia procumbens* Linn. ..	*c.*
9.	*Cryptostegia grandiflora* Br. ..	*a.*
10.	*Sida cordifolia* Lamk. ..	*c.*
11.	*Cordia serrata* Roxb. ..	*c.*
12.	*Sericostoma pauciflorum* Stocks. ..	*c.*
13.	*Cenchrus setigerus* Vahl. ..	*c.*
14.	*Eragrostis tremula* Hochst. ..	*c.*

IV. *Gymnosporia-Adhatoda* Association

1.	*Gymnosporia spinosa* (Forsk.) Fiori. ..	*d.*
2.	*Justicia adhatoda* Linn. ..	*co.d.*
3.	*Euphorbia royleana* Boiss. ..	*a.*
4.	*Euphorbia hirta* Linn. ..	*c.*
5.	*Euphorbia microphylla* Heyne. ..	*c.*
6.	*Acalypha malabarica* Muell. ..	*c.*
7.	*Portulaca quadrifida* Linn. ..	*r.*
8.	*Phyllanthus maderaspatensis* Linn. ..	*c.*
9.	*Bœrhavia diffusa* Linn. ..	*c.*

V. *Acacia-Zizyphus* Association

1.	*Acacia arabica* Willd.	*d.*
2.	*Zizyphus rotundifolia* Lamk.	*co.d.*
3.	*Justicia adhatoda* Linn.	*c.*
4.	*Pavonia odorata* Willd.	*c.*
5.	*Calotropis procera* Br.	*c.*
6.	*Artemisia vulgaris* Linn.	*c.*
7.	*Solanum xanthocarpum* Schard. & Wendl.	*c.*
8.	*Datura alba* Nees.	*c.*
9.	*Borreria hispida* (L.) Schum.	*c.*
10.	*Achyranthes aspera* Linn.	*c.*

VI. *Calotropis-Euphorbia* Association

1.	*Calotropis procera* Br.	*d.*
2.	*Euphorbia royleana* Boiss.	*co.d.*
3.	*Tephrosia purpurea* Pers.	*a.*
4.	*Pergularia dæmia* (Forsk.) Blatt. & Mc.	*c.*
5.	*Indigofera linifolia* Retz.	*c.*
6.	*Euphorbia hirta* Linn.	*c.*
7.	*Euphorbia microphylla* Heyne.	*c.*
8.	*Portulaca oleracea* Linn.	*c.*

VII. *Leptadenia-Tephrosia* Association

1.	*Leptadenia pyrotechnica* (Forsk.) Decne.	*d.*
2.	*Tephrosia purpurea* Pers.	*co.d.*
3.	*Prosopis spicigera* Linn.	*c.*
4.	*Zizyphus nummularia* Wt. et. Arn.	*r.*
5.	*Acacia arabica* Willd.	*r.*
6.	*Crotalaria burhia* Ham.	*a.*
7.	*Launæa aspleniifolia* Hk.f.	*c.*
8.	*Euphorbia hirta* Linn.	*c.*
9.	*Bærhavia diffusa* Linn.	*c.*
10.	*Datura alba* Linn.	*c.*
11.	*Argemone mexicana* Linn.	*c.*
12.	*Cenchrus setigerus* Vahl.	*c.*
13.	*Eragrostis tremula* Hochst.	*c.*
14.	*Tragus biflorus* Schult.	*c.*

The hydrophytic vegetation in Jaipur area is represented by *Typha* sp., *Eichhornia* sp., *Ceratophyllum* sp., *Utricularia* sp., *Scirpus* sp., *Vallisneria* sp., *Lemna* sp., *Hydrilla* sp., *Cyperus* sp. etc.

Note.—*d.*—dominant species.
co.d.—Co-dominant species.
a.—Abundant species.
c.—Common species.
r.—Rare species.

Discussion

The vegetation of Jaipur and some selected areas in Jaipur division representing different ecological habitats has been studied and plant associations growing in this area have been briefly outlined. The

factors which affect the growing vegetation have also been analysed and it is attempted to establish a correlation between the factors and the vegetation.

Jaipur division is one of the extensive tracts of Eastern Rajasthan and the types of ecological habitats surveyed in the area range from hilly tracts to sandy plains. The hills in the area represent the tectonic chains of the Aravali ranges and they differ from the main range of Aravali in having a low rainfall and their heights do not reach more than 500 to 700 metres anywhere in Rajasthan. Consequently the hills and the adjacent valleys support a poorer vegetation in comparison to the main range of the Aravalis. Mahabale and Kharadi (1946) have surveyed the vegetation of Mount Abu, the highest peak of the Aravali ranges. On the slopes of mountains and towards the base they have recorded species of *Capparis* and *Gymnosporia* which are characteristic of the sandy plains of the arid and semi-arid tracts of Rajasthan. Further up formations of *Boswellia serrata* and *Anogeissus pendula* are represented next with *Euphorbia royleana.*

It is interesting to note that the hill vegetation in Jaipur division is practically composed of the same elements as at lower heights of Mount Abu. It is thus evident that the tectonic mountainous chains in the Eastern Rajasthan undoubtedly represent a part of the Aravali range on the basis of the components of the vegetation.

The flora of the hilly areas in Western Rajasthan as pointed out by Sarup and Vyas (1953) is characterised by giant Euphorbias, *Anogeissus*, *Holoptelea*, *Cordia* and bushes of *Zizyphus*, *Capparis*, *Gymnosporia*, etc. There is thus considerable resemblance in the hilly flora of both Eastern and Western Rajasthan. However, the growth of the different species in the hills of Eastern Rajasthan is more profuse and thick. This fact should be correlated with the increased rainfall in the eastern parts.

The vegetation in the plains of Eastern Rajasthan is characterised by association of *Prosopis, Capparis*, *Gymnosporia*, *Calotropis*, *Leptadenia* and others which are reported from Western Rajasthan too. In some parts of Eastern Rajasthan there are extensive associations of *Salvadora*, *Zizyphus*, *Calligonum* and *Balanites* for several miles and in this respect Eastern Rajasthan mixes with Western Rajasthan.

The fact that the plain species can grow on the rocks is of considerable significance. Plants like *Capparis*, *Gymnosporia* and *Zizyphus* possess this adaptability and this very well speaks of their hardy nature and capacity to thrive in rocky as well as sandy situations.

In the present study a number of plant species both ephemerals and perennials were seen to be represented in mixed associations both on the hills and in the plains.

Two main zones of Jaipur division are surveyed in the present study. The sandy zone which merges with the sandy areas of Bikaner division constitute the Shekhawati area (see Joshi, 1956). This zone

is characterised by vast stretches of sandy plains with sand dunes of different heights. The climate of this zone is rather rigorous and is characterised by low annual rainfall and extremes of temperature. The second investigated zone is Jaipur and its neighbourhood which has got a better climate and the water resources and the water supply to the vegetation are of a better nature due to enhanced annual rainfall. The vegetational differences in these two zones are marked enough. The sandy zone supports a vegetation which is characteristic of the sandy plains of Western Rajasthan. The moist zone supports tree species which are represented at Mount Abu by *Boswellia serrata*, *Holoptelea integrifolia* and others. However, the nature of the vegetation in these zones is still of the semi-arid type since the rainy months are interrupted for a considerably long time.

The hydrophytic associations represented in this zone are characterised by an abundance of *Typha* and *Eichhornia* species. In this respect the eastern element differs a little from the western element but approaches the semi-arid zone of Uttar Pradesh and the moist peninsular areas where hydrophytes grow almost ruthlessly.

The soil conditions in the zone show considerable variations. The sandy areas have an acidic pH while in the hills and other humus containing zones the pH value reaches the alkaline side. It may, therefore, be possible that the plants growing in the sandy zones are *acidophilic* while those growing on the hills and other areas may be *basophilic*. However, such a classification cannot be done without further detailed studies on larger areas in Rajasthan.

The above stated features of the vegetation in this area clearly indicate that there is an admixture of the elements in the sandy plains and rocks. The extent of their growth is determined by the climatic conditions particularly available moisture. In view of the low availability of moisture, the vegetation remains to be of a semi-arid type with a tendency towards developing into a deciduous forest with increase in the annual rainfall.

Summary

(1) The present communication deals with a comparative study of the vegetation of some selected areas in Jaipur division.

(2) The climatic and biotic factors have been discussed.

(3) The soil analysis of some selected areas in Jaipur division is carried out at different depths.

(4) A detailed account of the vegetation and plant associations of different zones in the area is given.

(5) A comparison of the vegetation of this area with other areas shows that the hilly vegetation in Jaipur is practically composed of the same elements as at lower heights of Mount Abu. Moreover, there is considerable resemblance in the hilly flora of both Eastern and Western Rajasthan. The sandy plain flora of Jaipur and Shekhawati

also mixes with the Western Rajasthan and merges with the vegetation of sandy areas of Bikaner division. The hydrophytic vegetation of Eastern Rajasthan differs a little from Western Rajasthan but approaches the semi-arid zones of Uttar Pradesh and the moist peninsular areas.

(6) Depending upon the soil conditions the vegetation growing in the sandy zones may be called as *acidophilic* and that growing on rocks as *basophilic*, but this classification needs further detailed investigation.

(7) The vegetation is in general of semi-arid type with a tendency towards developing into a deciduous forest with increase in the annual rainfall.

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EMBRYOLOGY OF *BRASSICA JUNCEA* CZERN & COSS

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Introduction

Although descriptive embryology of flowering plants has been studied in considerable detail, information with reference to economic plants is rather meagre. This is probably due to the fact that the objective of studies made so far has been the delineation of phylogenetic relationship among the plants studied. While the importance of this approach cannot be overemphasised, the development of applied aspects of embryology is an essential desideratum. For, it is on the accuracy and precision of embryological information, that success in practical methods of either cultivating embryos from distant crosses or of explaining seed sterility in hybrids and in autotetraploids, or of studying the genetical consequences of phenomena like Renner effect, largely depends. Recognising, therefore, the importance of such fundamental studies in practical breeding, a series of studies have been initiated at the Division of Botany, Indian Agricultural Research Institute, on the descriptive embryology of major crop plants like wheat, oilseeds, pulses and vegetables. It is only to be expected that in general the embryology of crop plants will be in conformity with that of the nearest species worked out already. There might also be variations from well recognised patterns of development resulting from evolution under cultivation. This variation might be of little consequence phylogenetically, but might be important from breeding and genetical view-points.

The present paper records observations on *Brassica juncea*, one of the many oil-seed crops that are under this type of study at the Division of Botany, Indian Agricultural Research Institute. The first report of this series was by Ahuja and Bhaduri (1956) on another important oilseed crop *toria* (*Brassica campestris* var. *toria*).

Material and Methods

The material for this study was collected during the middle of January and the beginning of March 1956 from the experimental plots of the Division of Botany, Indian Agricultural Research Institute. Buds, flowers, fruits and seeds were fixed in formalin-acetic-alcohol and Navashin's fixative. Young ovaries were dissected out and fixed. For studying the post-fertilization stages ovaries were cut into convenient pieces of about 1 cm. in length to facilitate easy handling during sectioning. The customary methods of dehydration and imbedding were followed. Sections were cut at thickness varying from 5–20 microns depending upon age and thickness of the material. Slides

were stained in (i) Safranin-fast green, (ii) Heidenhain's iron-hæmatoxylin and (iii) Feulgen-fast green staining schedules. Safranin-fast green combination proved to be the best. For a study of microsporogenesis young buds were fixed in acetic-alcohol and also in Carnoy's fixing fluid.

Observations

Plate IX, Fig. 1 is a transverse section of a flower bud showing the arrangement of the various floral organs.

Microsporogenesis and male gametophyte.—The anthers are tetralocular. The anther wall at microspore mother cell stage comprises of four distinct layers, *viz.*, an outermost layer, the epidermis, followed by a single layer of endothecial cells, a third layer, and an innermost layer, the tapetum. Epidermis persists up to the time of dehiscence. The endothecium develops radial bands of fibrous thickenings. The cells of the middle layer divide periclinally giving rise to 2–3 layers which are crushed during the course of development and of which no trace is left at the time of the dehiscence of the anther. A few cells in the region of the connective also show fibrous thickenings like those of the endothecium. The tapetal cells are uninucleate to begin with but later become binucleate. With the onset of meiosis in the microspore mother cells the tapetal cells enlarge considerably and become vacuolated but remain intact. However, they disintegrate being presumably consumed and obliterated in the mature anther.

The dehiscence of the anther occurs along the line of partition between the two microsporangia on each side of the anther, *i.e.*, longitudinally.

During meiosis I (Pl. IX, Fig. 2) the micropsore mother cells increase in size and develop a thick mucilaginous wall around them. Wall formation occurs only after the completion of the second division resulting in the formation of tetrahedral, decussate and isobilateral types of tetrads (Pl. IX, Figs. 3–4). Soon after tetrad formation the mucilaginous matrix is consumed and the microspores separate. The newly separated microspores are thin-walled, a thick exine developing later. Pl. IX, Figs. 5–7 show the development of the male gametophyte. Shedding takes place at the 3-celled stage. Each pollen grain has three germ pores.

Megasporogenesis and female gametophyte.—The ovules are tenuinucellate and bitegmic. Each ovule arises as a small protuberance and becomes campylotropous by the time the mother cell stage is reached. The micropyle is directed towards the stylar end of the ovary. The vascular supply is also discernible in the funiculus (Text-Fig. 13).

The archesporium originates in the hypodermal layer. Either a single archesporial cell differentiates (Text-Fig. 1) or 2–3 archesporial cells may be found in the same nucellus (Text-Fig. 2). In the former case a parietal cell is cut off (Text-Figs. 3 and 4). The development in the latter case could not be traced. Meiosis in the megaspore mother

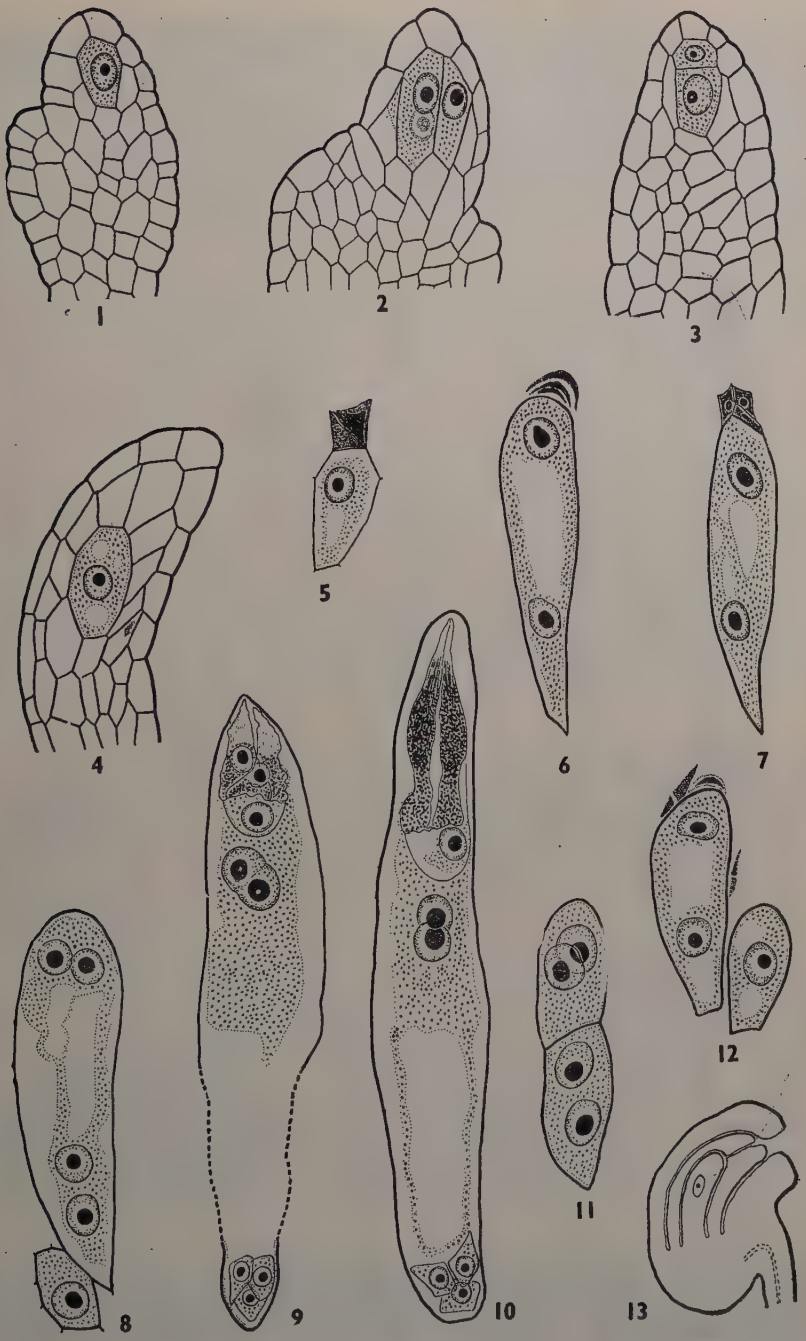
cell leads to the formation of a linear or T-shaped tetrad of megaspores (Text-Figs. 6 and 7). Generally the chalazal megaspore functions while the upper three degenerate (Text-Fig. 5). Their remnants are clearly visible. Three nuclear divisions lead to the formation of an 8-nucleate embryo-sac (Text-Figs. 6–10).

At the mature embryo-sac stage the upper portion of the embryo-sac lies in contact with the inner layer of the inner integument which forms the endothelium, the apical portion of the nucellus having been digested. An organised embryo-sac shows two synergids each having a filiform apparatus, basal vacuole and a nucleus situated in its neck (Text-Fig. 9). The synergids degenerate quite early (Text-Fig. 10). The egg is usually suspended between the two synergids. The two polar nuclei are similar to each other and lie together in the centre of the embryo-sac or more towards the egg apparatus. The three antipodals are uninucleate and prominent but degenerate early so that no trace of them remains in the post-fertilization stages. In *Brassica oleracea* (Thompson, 1933) the antipodals sometimes become multinucleate before degeneration. Such a condition is not met with in *B. juncea.* The remains of the nucellus extend towards the chalaza from the lower end of the embryo-sac. These gradually disappear in the post-fertilization stages. The condition shown in Text-Fig. 11 could arise as a result of functioning of two megaspores of a tetrad at the same time. Text-Fig. 12 shows a 2-nucleate embryo-sac and a functioning megaspore lying side by side in the same ovule. Twin embryo-sacs were observed in approximately 10 per cent. of the total number of the ovules studied, but none of these seemed to have reached the mature, organised stage.

Insects, chiefly bees, are the agents of pollination. An account of flowering and pollination is already given by Howard *et al.* (1915). The plants are predominantly cross-pollinated. But unlike *toria* and *B. nigra*, the plants are self-compatible.

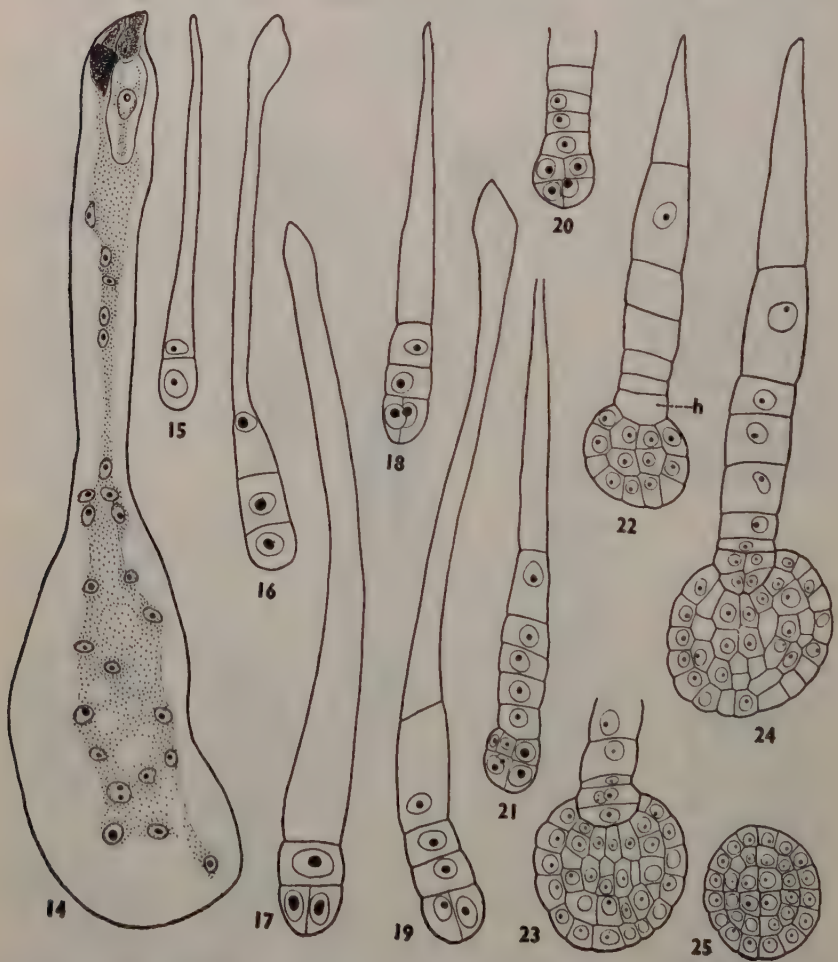
Endosperm.—The primary endosperm nucleus divides much before the zygote and the divisions are free nuclear in the beginning (Text-Fig. 14). Wall formation takes place only after the embryo has reached the late heart-shaped or the torpedo stage. Two deeply staining masses of endosperm nuclei are seen, one of which is found in the chalazal end of the embryo-sac while the other can be seen around the suspensor. Pearson (1933) has observed the same in *B. oleracea.* According to him the granular substance in which these endosperm nuclei are embedded is a vehicle for the transfer of the nutritive material for the embryo. Most of the endosperm tissue is consumed by the growing embryo and only a single layer (at places more) is left in the mature seed.

Embryo.—The zygote elongates and its nucleus travels towards its apical end (Text-Fig. 14). The first division is transverse followed by another transverse division (Text-Figs. 15 and 16). The apical cell of the 3-celled proembryo divides by a vertical wall (Text-Figs. 17). In *B. oleracea* (Thompson, 1933) the zygote produces, by several successive divisions, a row of cells. The filamentous proembryo usually consists of 6–8 cells before its terminal cell divides vertically.



TEXT-FIGS. 1–13

TEXT-FIGS. 1–13. *B. juncea*. Fig. 1. Hypodermal archesporial cell in the nucellus. Fig. 2. Three archesporial cells in the same nucellus. Fig. 3. L.S. nucellus showing a megaspore-mother cell with a parietal cell. Fig. 4. Same, slightly advanced stage. Fig. 5. Functional megaspore with degenerating megaspores. Figs. 6 and 7. Two-nucleate embryo sacs of linear and T-shaped tetrad respectively. Fig. 8. Four-nucleate embryo-sac with a sporogenous cell below it. Figs. 9 and 10. Mature organised embryo-sacs. Fig. 11. Twin embryo-sacs. Fig. 12. Two-nucleate embryo-sac and a functional megaspore found in the same nucellus. Fig. 13. L.S. ovule at megaspore mother cell stage. Figs. 1–12, ×525. Fig. 13, ×105.



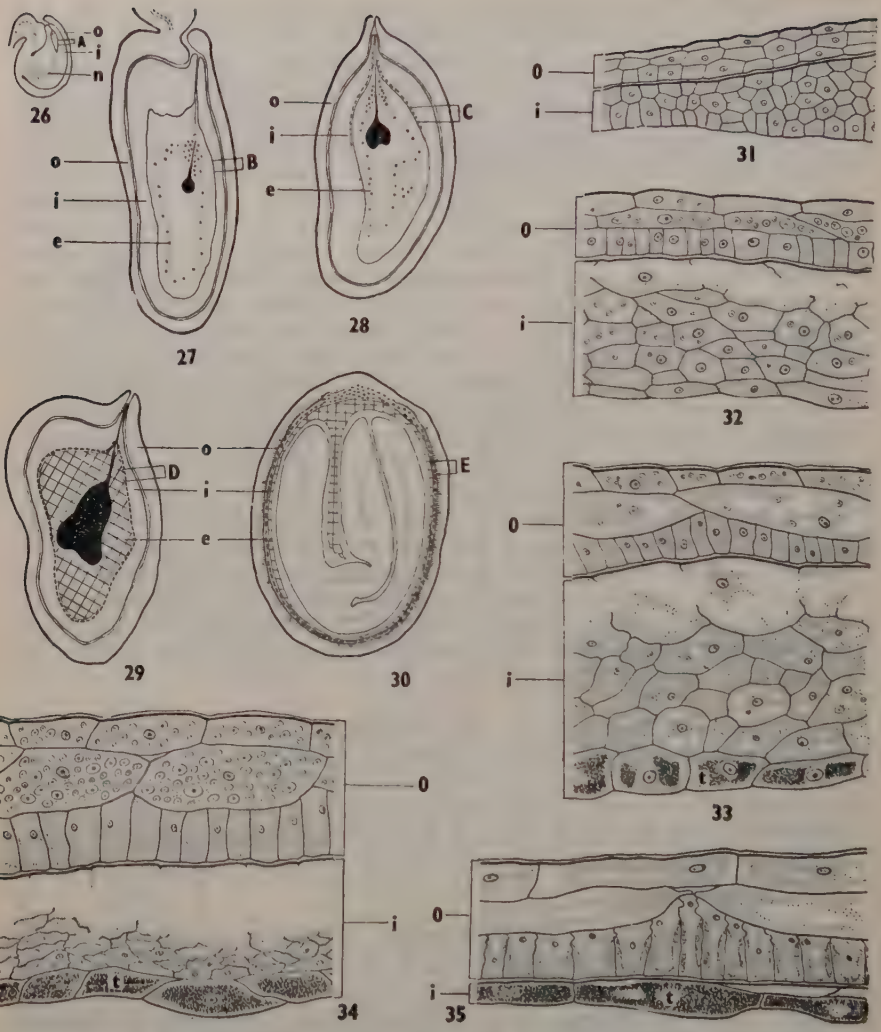
TEXT-FIGS. 14–25. *B. juncea* (*h*. Hypophysis). Fig. 14. Embryo-sac showing the elongating zygote and free endosperm nuclei. Figs. 15–19. 2–6-celled pro-embryos respectively. Figs. 20, 21. Quadrant and octant stages respectively. In Fig. 21, the two-cells on right side of the octant are still undivided. Figs. 22–24 show the behaviour of the hypophysis. Fig. 25. T.S. globular pro-embryo. All Figs., ×350.

Text-Figs. 18 and 19 show 5- and 6-celled proembryos. The first division in the terminal cell is followed by another division at right angles to it resulting in a quadrant (Text-Fig. 20). This is followed by an octant stage (Text-Fig. 21). As reported in *Capsella bursa-pastoris* (Souèges, 1919) and *Brassica campestris* var. *toria* (Ahuja and Bhaduri, 1956), of these eight cells the upper tier of four cells gives rise to the stem tip and the two cotyledons and the lower tier of four cells to the hypocotyl and the initials of the central cylinder of the stem. Due to subsequent transverse divisions in the suspensor cells a row of 7–10 cells is formed. There are no longitudinal divisions in the suspensor cells as is sometimes found in *Alyssum macrocarpum* (Riddle, 1898). The basal cell of the suspensor is very long just as in *toria* (Ahuja and Bhaduri, 1956), *Alyssum macrocarpum* (Riddle, 1898), *B. oleracea* (Pearson, 1933) and *Eruca sativa* (Lebègue, 1952). All these differ from *Capsella bursa-pastoris* (Schaffner, 1906; Souèges, 1919; Lebègue, 1952) where the basal suspensor cell is swollen or vesicular. The first division of the hypophysis *h* shown in Text-Fig. 22 is transverse followed by two vertical divisions (Text-Figs. 23 and 24). In this point again it resembles *toria* and *Capsella*. The hypophysis gives rise to root and root cap. Further, the embryo passes through the heart-shaped and torpedo stages and finally the 2 cotyledons grow and become conduplicate (Text-Fig. 35). The cells of the cotyledons in a mature embryo are full of fatty stored material, which when expressed, is the mustard oil of commerce. Text-Fig. 25 is a transverse section of a globular proembryo. On the whole the sequence of embryo development follows the same pattern as reported in *B. campestris* var. *toria*.

Seed-Coat.—The cells of the integuments are modified in several ways in the formation of the seed-coat (Text-Figs. 26–35). At the mature embryo-sac stage (Text-Figs. 26 and 31) the inner integument is narrow, 2–4-layered, at the micropylar end but is broad on the sides and the base of the ovule where it is 12 or more cells thick. The outer integument is comparatively thin and is 3-layered only (at places it may be 4-layered).

During the course of development, the outer two layers of the outer integument get filled with starch while the cells of its innermost or the third layer become radially elongated and are arranged compactly (Text-Figs. 32–34). The outermost layer of the outer integument or the epidermis develops a thin cuticle which persists in the mature seed. By the time the embryo reaches the heart-shaped or torpedo stage the fleshy inner integument shows the presence of tannin-like substance in its innermost one or two layers only (Text-Figs. 28, 29, 33 and 34), the rest of the layers contain starch grains (Text-Figs. 32–34).

In the mature seed (Text-Figs. 30 and 35) all the 3 layers of the outer integument persist. The innermost layer of compactly arranged cells of the outer integument develops prominent thickenings on the radial and inner tangential walls of its cells, their outer tangential walls remaining thin. This constitutes the supporting layer. Of the fleshy



TEXT-FIGS. 26–35. (*e.*, Endosperm; *i.*, Inner integument; *n.*, Nucellus; *o.*, Outer integument; *t.*, Tannin). Figs. 26–30. L.S. Ovules at mature embryo-sac, globular pro-embryo, heart shaped, torpedo and mature stage of the embryo respectively. Figs. 31–35. Enlarged portions of integuments marked A, B, C, D and E in Figs. 26–30 respectively. Figs. 26–29, ×27. Fig. 30, ×15. Figs. 31–35, ×267.

inner integument the layer (or layers) with tannin filled cells together with one or two other layers persists, all the others being crushed during development. In *B. oleracea* the heavy walled supporting layer is reported to originate in the inner integument (Thompson, 1933). This differs from *B. juncea* where the origin of such a layer is found to be in the outer integument.

Mature Seed.—The mature seed of *B. juncea* is reddish brown to dark brown in colour, globose in shape and shows distinct reticulations on the surface of its coat. It is exalbuminous, enclosing a single horse-shoe-shaped dicotyledonous embryo which occupies the entire space in the seed except for a very small amount of endosperm.

The presence of starch in the seed-coat and oil in cotyledons was tested by Iodine and Sudan III respectively which gave positive results.

Discussion

As pointed out earlier in the introduction, the embryological trend in *B. juncea* is, in the main, similar to that of its related species like *B. oleracea* or *campestris* reported earlier. However, two points need brief discussion. First is the presence or absence of nucellus in the mature seed. The mature embryo-sac comes to lie in direct contact with the innermost layer of the inner integument which forms the endothelium. The nucellar tissue at this stage is found only at the chalazal end of the embryo-sac the rest of it having been crushed and obliterated because of the expansion of the growing embryo-sac. A similar condition is reported in *Brassica oleracea* (Thompson, 1933) also. In *B. juncea*, the remaining nucellar cells in the chalazal end are also gradually consumed during post-fertilization stages so that eventually no trace of nucellus is left in the mature seed. On the other hand, in a seed of *B. oleracea*, a few layered tissue inner to the inner integument is interpreted as the nucellus by Thompson (1933). This does not seem to be correct for, once the embryo-sac comes in direct contact with the inner integument, a new nucellus cannot arise in between the two. Pearson (1933) has also reported in *B. oleracea* the nucellus to be completely disappearing shortly after fertilization. At the mature seed stage, therefore, the tissue inner to the pigmented layer (the pigmented layer being the tannin filled persisting layer of the inner integument) is the remnant of endosperm and not of the nucellus in *B. juncea* as well as in *B. oleracea*. It is very likely that the same is true for the other species of this genus. In *Raphanus sativus* a member of the same family the seed-coat consists of an epidermis followed by subepidermal layer, "palisade tissue" and lastly the pigmented layer. Next to the pigmented layer lie the remains of the endosperm. In this case as well there is a complete absence of nucellus in the mature seed (Hayward 1938).

The second point of interest, which may be mentioned here, is regarding the origin of the thick-walled supporting layer of the seed-coat in *Brassica*. Both the integuments take part in seed-coat formation. It has been found that in *B. juncea*, *B. campestris* var. *toria* and *B. nigra* the innermost layer of the 3–4-layered outer integument develops thickenings and forms the supporting layer. This supporting layer is incorrectly reported by some previous authors as "palisade tissue". According to Thompson (1933) such heavy walled layer together with a pigmented layer in *B. oleracea* originates from the inner integument. But, he does not give a series of figures to show the exact course of modification in the two integuments. It is quite

likely that *B. oleracea* is also similar to the other species so far as the origin of the supporting layer is concerned. This, however, is to be confirmed by reinvestigation. Although they differ considerably in their external morphology and cytology the different species of *Brassica*, *viz.*, *B. oleracea* (Thompson, 1933; Pearson, 1933), *B. compestris* var. *toria* (Ahjua and Bhaduri, 1956) and *B. nigra* (under investigation) show similar life-history from the embryological point of view.

Summary

Microsporogenesis and the development of male gametophyte are normal. Tapetum is glandular; its cells become binucleate at the time of reduction division. Simultaneous reduction divisions result in the formation of tetrads of isobilateral, tetrahedral and decussate types. Shedding takes place at the 3-celled stage. The campylotropous ovules are tenuinucellate and bitegmic. Archesporium may be single-celled or multicelled. Development of the embryo-sac is of the Polygonum type. Twin embryo-sacs occur occasionally. Endosperm is free nuclear to begin with but later it becomes cellular. Embryo development follows the *Capsella* variation. Development of seed-coat has been studied and a comparison with previously studied species is made. Mature seed is exalbuminous with a single dicotyledonous embryo.

The work reported in this paper was carried on partly when the author was a Research Fellow, and partly while on the staff of the scheme for cytological studies on some oilseed crops of India. The author's thanks are due to the Director, Indian Agricultural Research Institute, and the Indian Central Oilseeds Committee and also to Dr. S. M. Sikka, Head of the Division of Botany, for the keen interest he envinced in this study and for kindly providing her the necessary facilities for this work. She is thankful to Mr. S. S. Rajan for his guidance throughout the work and for going through the manuscript.

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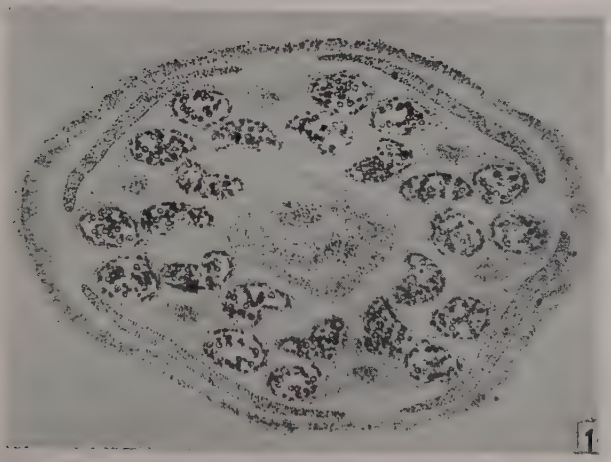

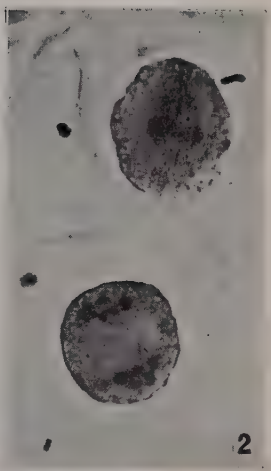

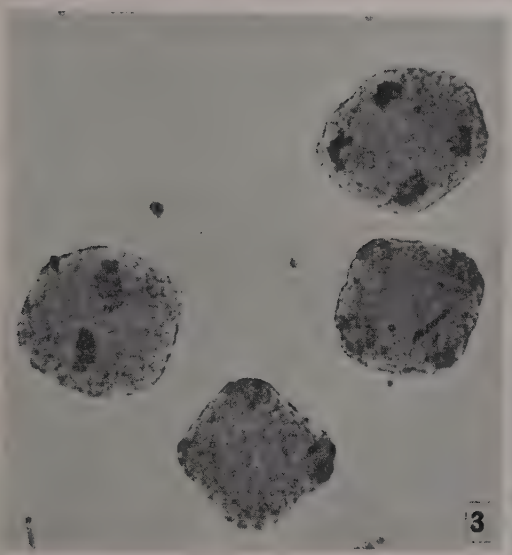

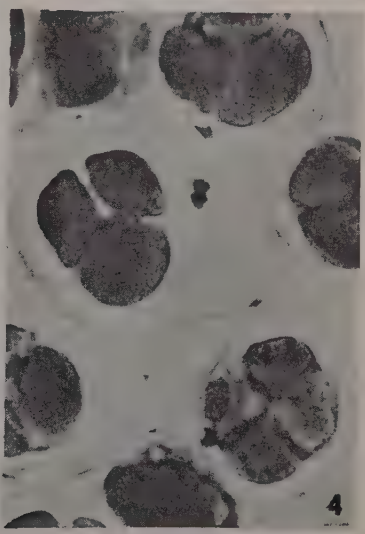

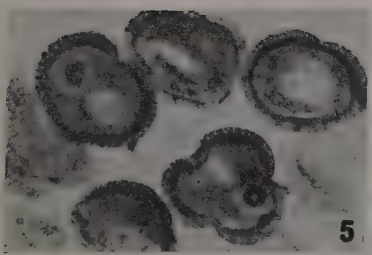

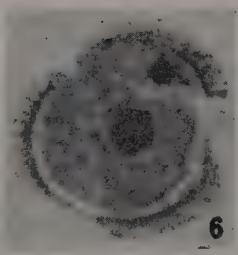

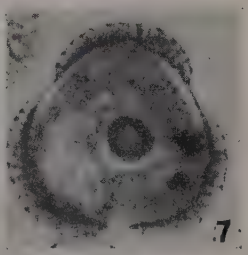

K. Sulbha

Explanation of Plate

Figs. 1–7. *Brassica juncea*

Fig. 1. T. S. flower bud, ×100.

Fig. 2. Microspore mother cells at metaphase and anaphase, ×900.

Fig. 3. Microspore mother cells undergoing meiosis II, ×900.

Fig. 4. Microspore tetrads, ×900.

Fig. 5. Uninucleate pollen grain, ×1350.

Figs. 6 & 7. 2-Celled and 3-celled pollen grains respectively, ×2,250.

SPERMATOGENESIS IN *NOTOTHYLAS LEVIERI* SCHFFN.*

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Introduction

Although in the past several contributions have been made on the spermatogenesis in liverworts, as far as the author is aware, not much work has been done on the Anthrocerotales. Campbell (1903) has given an outline of the process in *Dendroceros* while Bagchee (1924) has described the details of spermatogenesis in *Phæoceros lævis* (L.) Prosk. The remaining genera of the group have not received any attention so far in this respect. It was, therefore, thought advisable to follow the process in *Notothylas levieri* Schffn. which grows abundantly in India. The life-history of two common Indian species of the genus, *N. indica* Kash. and *N. levieri* Schffn., has been pursued by Pandé (1932, 1934), who also made a preliminary study of the spermatogenesis in the latter and communicated a note to the Twenty-first Session of the Indian Science Congress, Bombay (1934 *a*). The present investigation by the author gives a more or less detailed study of the spermatogenesis in *Notothylas levieri*.

Material and Method

Notothylas levieri grows abundantly at several places in the Himalayas and the Satpuras. The growing season of the plant is from July to October. The species is protandrous; antheridia making their appearance on the dorsal side of the thallus while the plants are very young. They develop endogenously in the normal way and usually three to four antheridia occur inside an antheridial chamber. Sometimes, however, the number is larger. Material for this study was collected by the author from Naini Tal (7,000 feet) and Mussoorie (6,000 to 7,000 feet) in the Western Himalayas and Pachmarhi (3,500 feet) in the Satpuras.

Fixation was invariably done in the field. The thalli bearing antheridia were cut into small pieces and fixed in Farmer's fluid, chrom-acetic acid, Flemming's fluid and Benda's fixative. Some material, earlier collected by Dr. Pandé, was also very kindly passed on to the author. The material was thoroughly washed according to the nature

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* Contribution from the Botany Department, Lucknow University, New Series, No. 22.

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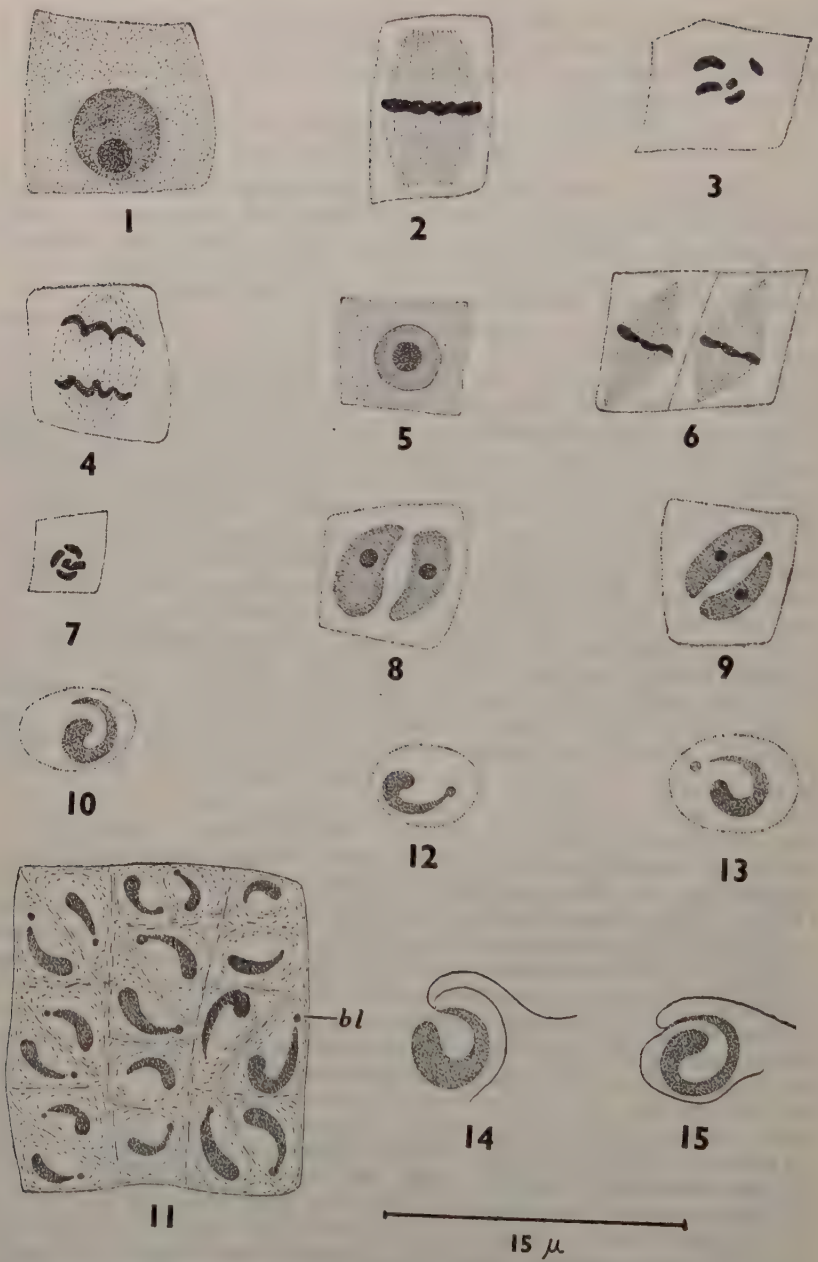
of the fixatives, and then gradually dehydrated and cleared in xylol and embedded in paraffin wax. Sections were cut 3 to 6 μ thick and stained in Heidenhain's iron-alum hæmatoxylin and saffranin, gentian violet and orange G.

Description

Unlike most other liverworts the spermatogenous cells in a segment of the antheridium, in *Notothylas levieri*, are rarely seen to divide simultaneously. The divisions are, however, very rapid and ultimately produce a large mass of minute cubical spermatid mother cells. Fig. 1 shows a cell of the spermatogenous tissue in the resting stage. It has a large nucleus with a prominent nucleolus, and is filled with finely granular cytoplasm. Fig. 2 shows the lateral view of the metaphase stage. The axis of the spindle lies along the longer axis of the cell. The poles may be either broad or pointed. Fig. 3 gives the polar view of the metaphase stage. In several cases the chromosomes could be counted more or less accurately (Figs. 3 and 7). The haploid number of chromosomes is five. This confirms the observations of Mehra and Handoo (1953) for this species. According to Tatuno (1941) the haploid number of chromosomes in *N. japonica* is six. Fig. 4 shows the anaphase stage, in lateral view. The spindle is clearly defined. The cells of the spermatogenous tissue divide repeatedly and produce a large number of spermatid mother cells which are very small and cubical in form Fig. 5. Each of the spermatid mother cell contains a large nucleus with a prominent nucleolus. Fig. 6 shows the lateral view of the metaphase stage in the division of the spermatid mother cells. The spindle is clearly seen and is invariably polar. Fig. 7 shows the metaphase stage in polar view. The other stages in the process of division were not seen. Figs. 8 and 9 show two pairs of sister spermatids. These are more or less crescent-shaped and each has a prominent nucleolus. As in *Phæoceros lævis* (Bagchee, 1924), in *Notothylas levieri* also no wall is formed between the sister spermatids. In *Riccardia levieri* Schffn. and *Pallavicinia* cf. *lyellii* (Hook.) Gray (from Canara), the author has seen that the two sister spermatids are separated by a definite membrane. Fig. 10 shows a spermatid older than those shown in Figs. 8 and 9. Upto this stage no sign of a blepharoplast could be observed. The walls of the spermatid mother cells get gelatinised forming a mass of mucilage which surrounds the young spermatids which are either triangular or crescent-shaped as in the case of *Phæoceros lævis* (Bagchee, 1924). Figure 11 shows a few spermatids. In some of these the blepharoplast (*bl*) is seen. Two of the stages in the formation of the blepharoplast are shown in Figs. 12 and 13. The exact origin of the blepharoplast could not be traced. In *Phæoceros lævis* (Bagchee, 1924), the blepharoplast arises as a result of fragmentation from the main mass of chromatin. It may be that in *N. levieri* also it arises in the same way. Figs. 14 and 15 show mature spermatozoids. Each spermatozoid has a pair of flagellæ. The origin of flagellæ could not be traced. No centrosome has been seen at any stage of the divisions.



FIGS. 1–15. *Notothylas levieri* Schffn. Fig. 1. A spermatogenous cell at the resting stage. Fig. 2. Metaphase stage (lateral view) in the spermatogenous cell. Fig. 3. Metaphase stage (polar view) in the spermatogenous cell. Fig. 4. Anaphase stage. Fig. 5. Spermatid mother cell. Fig. 6. Metaphase stage (lateral view)

in the spermatid mother cell. Fig. 7. Metaphase stage (polar view) in the spermatid mother cell. Figs. 8–9. Sister spermatids. Fig. 10. A spermatid, older than in Figs. 8 and 9. Fig. 11. Spermatids in different stages of development (*bl.*, blepharoplast). Figs. 12–13. Stages showing the formation of blepharoplast. Figs. 14–15. Mature spermatozoids.

Summary

1. The haploid number of chromosomes in *N. levieri* Schffn. is five.

2. No centrosome was observed at any stage of the divisions. The blepharoplast appears after the formation of the spermatids.

3. There is no separating membrane between the sister spermatids.

Acknowledgment

The author is indebted to Dr. S. K. Pandé for his able guidance throughout the progress of this work. He is also thankful to the Scientific Research Committee, Uttar Pradesh, for a grant which has greatly facilitated this work.

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KUTILAKESOPSIS, A NEW GENUS OF TUBERCULARIACEÆ FROM NORTH-EAST INDIA

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An interesting tubercullariaceous fungus was isolated from stem pieces of *Albizzia richardiana* collected from Dooars, North-East India. The plants were found to be affected by a species of *Phomopsis* and when the stem bits bearing the fructifications were incubated in moist chamber at the laboratory temperature, in about a week's time sporodochia of a hitherto undescribed fungus were found to develop in great profusion.

The sporodochia are at first immersed in the host tissue but later on become erumpent. They are, when young, white in colour turning pale olive-green with age. They are cushion-shaped and typically sessile, measuring up to 3 mm. in diameter and up to 400 μ in height. The sporodochia are beset with characteristically undulate setæ which are brown in colour. The mycelium of the fungus is intercellular in the tissues of the plant and profusely branched, hyaline, septate, measuring up to 4 μ in diameter, thickly interwoven at the base forming a loose stroma, and expanding above into a hymenial layer which is interrupted by the sterile setæ. The conidiophores are repeatedly branched in an irregular racemose pattern. The ultimate branches (phialides) are closely aggregated to form the fertile upper layer of the sporodochium. The phialides are long, cylindrical, hyaline, slightly wider at the base and tapering towards the apex, measuring on average $18{\cdot}8\times1{\cdot}5\,\mu$ (range: $16{\cdot}0$–$28{\cdot}8\times0{\cdot}8$–$2{\cdot}3\,\mu$) and mostly $17{\cdot}6\times1{\cdot}6\,\mu$. The setæ arise as unbranched laterals from thickly interwoven sporodochial matrix. They are narrow and thin-walled at the base, thick-walled and pale to deep brown above, presenting an undulate appearance due to the formation of lax spirals and up to 8-septate. The coloured part of the setæ is beset with dense verrucosities and projects well above the fertile layer of the sporodochium. Since the lower part of the setæ is hyaline and indistinguishable from the matrix of the sporodochium, it was possible to measure the coloured portion only which was found to be on an average $160\times7\,\mu$ (range: 110–240×6–$10\,\mu$). The setæ are mostly unbranched but in a few instances they are forked terminally. The conidia are produced singly, successively and acrogenously on the phialides, hyaline, one-septate, smooth-walled, cylindrical to sub-elliptic in shape, biguttulate, with an indistinctly formed mamillate base, measuring on an average $13{\cdot}5\times2{\cdot}0\,\mu$ (range: $9{\cdot}6$–$16{\cdot}8\times1{\cdot}6$–$3{\cdot}2\,\mu$) and mostly $14{\cdot}4\times1{\cdot}9\,\mu$. The conidia are produced in great profusion both in nature and in culture.

Cultural Characters of the Fungus

The fungus makes good growth on common laboratory media. The following are the cultural characters of the fungus as exhibited on oat meal agar.

Growth is woolly and cottony to begin with and after 5 to 6 days surface of the colony presents dense funiculose appearance. Spore formation begins in about 4 days after inoculation on to the medium and discrete sporodochia are discernible after 6 to 8 days. The sporodochia are rather byssoid, white at first, turning pale yellow-green with the age and are up to 4 mm. in diameter at the broadest part. The conidia in young cultures are borne on the extremities of the mycelial filaments that comprise the funiculose growth of the fungus in culture or on short laterals formed on them. The conidia are successively abstricted at the tip of the phialides and remain aggregated in a cephalosporium-like head. With the aging of the culture, the mycelium of the funiculose part becomes highly ramified assuming the appearance of a typical sporodochium. Setæ are found to be formed as short unbranched laterals intertwined in the funiculose part and they are evident even on the third or fourth day of the culture. The mycelium is up to 4 μ in diameter. The sterile setæ measuring on an average $200\times4\,\mu$ (range: 150–300×3–6 μ), phialides: average, $23\cdot6\times2\cdot2\,\mu$ (range: 19·0–32·0×1·6–3·2 μ) and mostly $25\cdot6\times2\cdot3\,\mu$. Spores are cylindrical, smooth-walled, hyaline, continuous first, later becoming 1-septate, submamillate at the base, measuring on an average $13\cdot8\times3\cdot6\,\mu$ (range: 9·6–16·8×2·4–4·8 μ) and mostly $15\cdot0\times3\cdot2\,\mu$.

Thus, it is found, in culture, the fungus has longer setæ and spores that are wider than those found on material in nature.

The typically branched conidiophores with a basal loose cottony stroma and the uniseptate spores characteristic of the fungus suggest that its position is undoubtedly in the didymosporous Tuberculariaceæ of the fungi imperfecti. Notwithstanding the hyaline nature of the conidia and conidiophores, the presence of pale brown to fuscous brown sterile setæ would place the fungus in the Dematieæ.

The fungus has a superficial resemblance to *Periolopsis* Maire (Saccardo, 1931) which was classified as a mucidinous amerosporous genus of the Tuberculariaceæ by its author. Our fungus bears certain similarity to the above genus in possessing somewhat circinnate or spirally coiled setæ which are brown in colour and verrucose at the free end but differs from it in having well-branched conidiophores and typically acrogenous conidia that are didymosporous. *Periolopsis* produces conidia that are acro-pleurogenous. *Leptotrichum* Corda (Saccardo, 1884, p. 691) has sporodochia which are typically superficial, with setæ that are filiform, continuous, erect and conidiophores that are obsolete. *Trichodochium*, a monotypic genus, was described by Sydow (1927) growing on *Rapanea pellucido-punctata* in Costa Rica. The genus was characterized as follows:—

"Sporodochia sparsa, superficialia, centro hypostromate, conico in stromatibus affixa, contextu minute celluloso, jere opace atro brunneo, ad margineam setis longis simplicibus, plus minusve curvatis, atro-brunneis obsita, conidia oblonga vel oblongo-cylindracea, bicellularia, pellucide atro-brunnea, in cellulis parum elongatis superfici sporodochiorum catenulatim oriunda."

From the above description it is clear that our fungus differs from it in having sterile setæ throughout the sporodochium. Apart from this difference, *Trichodocium disseminatum* has conidia that are typically catenulate and pale to deep brown in colour. Our fungus differs from *Fusisporella* Speg. (Saccardo, 1913), *Gymnodochium* Massee and Salm. (Saccardo, 1908), *Cosmariospora* Sacc. (Saccardo, 1884, p. 690), *Patouillardiella* Speg. (Saccardo, 1892), *Epiclinium* Fr. (Saccardo, 1884, p. 754), *Pucciniopsis* Speg. and *Anomomyces* Höhnel (Clements and Shear, 1931) and *Didymothozetia* Rangel (Ainsworth and Bisby, 1954) in possessing sporodochia which are typically setulose, the setæ being pale to deep brown, verrucose and undulate.

Mention must be made of another interesting fungus, *Kutilakesa* which was described recently by Subramanian (1956) from the University Botany Laboratory, Madras. The fungus was found growing on dead leaves of *Sansevieria* sp. in the campus of the University Botany Laboratory. This fungus is distinguished from *Periolopsis* in producing conidia that are oval to elliptic and typically acrogenous. Our fungus bears close resemblance to *Kutilakesa* in possessing characteristically undulate or loosely spiral sterile brown setæ that are verrucose but differs from it in being always sessile, erumpent with irregularly ramose conidiophores and the typically didymosporous conidia. Therefore, we propose a new genus to accommodate our fungus. The generic name is *Kutilakesopsis*, indicating its superficial resemblance to the aforesaid genus *Kutilakesa* of Subramanian (*op. cit.*), a name derived from the Sanskrit कुटिलकेश (*Kutilakesa* meaning: curly-haired) suggestive of the undulate sterile setæ characteristic of the two fungi.

Kutilakesopsis Agnihothrudu et G. C. S. Barua Gen. Nov.

Pertinet ad Fungos Imperfectos, ad Moniliales, Tuberculariaceas, Hyalodidymas. Sporodochia pulvinata, primo immersa, tum erumpentia, typice sessilia, setulosa. Setæ simplices, raro furcatæ ad apicem, pallide brunnea vel alte fuscæ colore, verrucosæ ad apicem liberum, septatæ, undulatæ, subcircinnatæ vel lax spirales dispersæ per sporodochium. Conidiophori dense intertexti, irregulariter furcati, septati, phialidibus efformantibus hymenium compactum. Conidia producta singulariter, acrogene atque successive phialidibus insidentia, cylindrica vel subelliptica, lævibus parietibus prædita, hyalina, bis cellulata. Species typica sequens.

Fungus imperfectus, Moniliales, Tuberculariaceæ, Hyalodidymæ. Sporodochia cushion-shaped, immersed first, becoming erumpent later, typically sessile, setulose. Setæ simple, rarely furcate at the top, pale brown to deep fuscous in colour, verrucose at the free end, septate,

undulate, subcircinate or loosely spiral, dispersed throughout the sporodochium. Conidiophores densely interwoven, irregularly ramose, septate, the phialides forming a densely packed hymenium. Conidia produced singly, acrogenously and successively on phialides, cylindric or subelliptic smooth-walled, hyaline, 2-celled.

The specific name is after Mr. R. I. Macalpine, Senior Advisory Officer, West Bengal Branch of the Scientific Department of the Indian Tea Association, who collected the fungus.

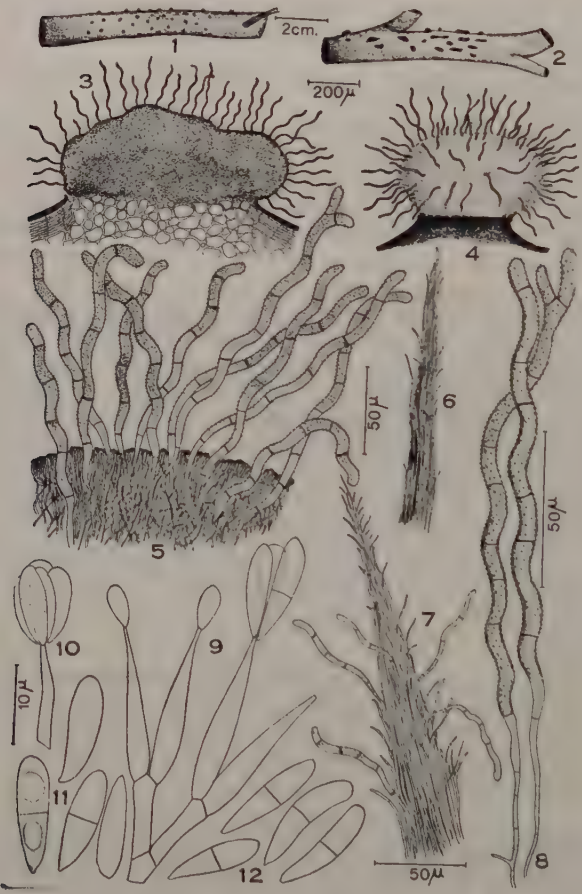
Kutilakesopsis macalpineæ Agnihothrudu et G.C.S. Barua Sp. Nov.

Sporodochia discreta, immersa in textus plantæ hospitis, postæ erumpentia, hemisphærica vel subglobosa vel pulvinifolia, primo alba, tum evadentia pallide lutea demum olivaceo-lutea, typice sessilia, diametientia 0·5–3·0 mm., usque ad 4 mm. sub cultura, 100–370 μ alta, setulosa. Setæ erectæ, ut plurimum simplices, raro terminaliter furcatæ, angustæ, leves atque hyalinæ infra, evadentes latiores, crassioribus parietibus præditæ, pallide vel alte brunneæ atque fortiter verrucosæ ad apicem, usque octies septatæ, undulatæ, subcircinnatæ vel lax spirales 110–315 μ longæ, 2–4 μ latæ ad basim, 3–10 μ latæ ad apicem, dispersæ per sporodochium interrumpentes superficiem hymenialem. Conidiophori tenuibus parietibus præditi, hyalini, septati irregulariter ramosi, ramis ultimis (phialidibus) proxime juxtapositis ad efformandam superficiem fertilem. Phialides simplices, hyalinæ, cylindricæ, angustæ ad apicem, multo latiores ad basim, magnitudine media 21·2×1·8 μ, variante inter 16·0–32·0×0·8–3·2 μ. Conidia successive et singulariter producta acrogene phialidibus insidentia, cylindrica vel subelliptica, apice obtuso, basi papillata, tenuia et levibus parietibus prædita, hyalina, semel septata, non-numquam constricta ad septum, biguttulata, magnitudine media 13·6×2·8 μ, variante inter 9·6–16·8×1·6–4·8 μ, ut plurimum 14·7×2·4 μ.

Typus lectus in caulibus viventibus *Albizziæ richardianæ* in Baradighi-Tea Estate, Dooars, in Bengalia occidentali a R.I. Macalpine die 22 mensis martii anni 1957, et positus in herbario Stationis Experimentalis Tocklai sub numero 25 et herbario laboratorii botanici Universitatis Madraspatensis. sub memers 1895.

Sporodochia separate, immersed in the host tissue, becoming erumpent later, hemispherical to subglobose or cushion- or button-shaped, white at first turning pale olive green through pale yellow, typically sessile, in culture measuring 0·5–3 mm., up to 4·0 mm., in diameter, 100–370 μ in height, setulose. Setæ erect, mostly simple, rarely terminally furcate, narrow, smooth and hyaline below, becoming broader, thick-walled, pale brown to deep brown and strongly verrucose at the tip, with up to 8-septa, undulate, subcircinnate or lax spiral, measuring 110–315 μ long, 2–4 μ wide at the base, 3–10 μ at the apex, interspersed throughout the sporodochium interrupting the hymenial surface. Conidiophores thin-walled, hyaline, septate, irregularly ramose, the ultimate branchlets (phialides) closely juxtaposed to form the fertile layer. Phialides simple, hyaline, cylindrical, narrow at the

top, rather broader at the base, measuring on an average $21 \cdot 2 \times 1 \cdot 8\,\mu$, range, $16 \cdot 0$–$32 \cdot 0 \times 0 \cdot 8$–$3 \cdot 2\,\mu$. Conidia produced successively, singly, acrogenously on phialides cylindrical to subelliptic in shape with an obtuse apex and faintly papillate base, thin- and smooth-walled, hyaline, 1-septate, at times constricted at the septum, biguttulate, measuring on an average $13 \cdot 6 \times 2 \cdot 8\,\mu$, range, $9 \cdot 6$–$16 \cdot 8 \times 1 \cdot 6$–$4 \cdot 8\,\mu$ and mostly $14 \cdot 7 \times 2 \cdot 4\,\mu$.



FIGS. 1–12. Fig. 1. Sporodochia on twigs of *Albizzia richardiana* (Herb. T.E.S. No. 25). Fig. 2. Sporodochia on sterilized twigs of *Albizzia procera* (Herb. T.E.S. No. 103). Fig. 3. Longitudinal section of the erumpent sporodochium. Fig. 4. An enlarged erumpent, sessile sporodochium. Fig. 5. Part of the sporodochium showing the sterile setæ. Fig. 6. Funiculose growth of mycelium in culture. Fig. 7. Funiculose growth in culture showing the formation of sterile setæ. Fig. 8. Sterile setæ. Fig. 9. Ultimate units (phialides) of the conidiophore. Fig. 10. Conidia produced in a cephalosporium-like head in culture. Fig. 11. Conidia in culture. Fig. 12. Conidia in nature. (3, 4, 5, 8 and 12 drawn from Herb. T.E.S. No. 25. 6, 7, 9 10, and 11 from Herb. T.E.S. No. 102.)

Type on stem pieces of *Albizzia richardiana* plants growing in Baradighi Tea Estate, Dooars, West Bengal, collected by R. I. Macalpine on 22nd of March 1957, deposited in the Mycological Herbarium, Tocklai Experimental Station, Assam, No. 25 and in the Herbarium of The University Botany Laboratory, Madras, Herb. MUBL No. 1895.

A fungus identical to the above described was collected by one of us (V. A.) on dead twigs of *Albizzia procera* from the campus of Tocklai Experimental Station on 18th of November 1956 but, since the material available was too meagre to permit conclusive identity only a couple of slides were prepared from it and deposited in the Mycological Herbarium, Tocklai Experimental Station, No. 12. Recently another collection of the same fungus was made on dead twigs of *Cassia lævigata*, by Mr. H. K. Phukon, dated 3rd May 1957, Herb. T.E.S. No. 104.

Acknowledgements

We are much thankful to the Director, Tocklai Experimental Station, for permitting to publish this paper and to Mr. K. C. Sarmah, the Mycologist, for his encouragement. We also wish to record our sincere gratitude to Professor Dr. T. S. Sadasivan and Dr. C. V. Subramanian for their valuable criticism, to Rev. Fr. Dr. H. Santapau, S.J., of St. Xavier's College, Bombay, for kindly rendering the Latin diagnosis, to Dr. R. Kalyanasundaram of the Institute für Spezielle Botanik, Eidg. Technische Hochschule, Zürich, and to Dr. M. C. Das, Principal, Assam Agricultural College, for making available relevant literature during the course of study of the fungus.

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SOME GROWTH-REGULATING SUBSTANCES FROM BARLEY LEAVES*

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Recent applications of improved analytical methods have brought to light the existence of a number of growth-promoting substances in plants other than indole acetic acid. This subject has been ably reviewed by Gordon (1954). The technique of paper chromatography has been applied extensively to the detection and characterization of a number of plant growth-promoting as also growth-inhibiting substances (see Sen, 1955). The occurrence of some growth-regulating substances in Wintex barley leaves is described in this paper.

Experimental

Wintex barley (*Hordeum vulgare* L.) plants were grown in the greenhouse on gravel beds with nutrient solutions. Four week-old plants after being weighed were taken in a Waring Blendor and crushed and extracted in ten times the volume of 80% ethanol for five minutes. The extract was evaporated to a small volume *in vacuo* and chromatographed on Whatman No. 1 filter-paper in isopropanol-ammonia-water (10 : 1 : 1) which has been found to be one of the best solvents for chromatography of indole compounds (Sen and Leopold, 1954). The ascending method of chromatography was followed. Ferric chloride-perchloric acid reagent of Gordon and Weber (1951) was sprayed on the dried chromatograms for location of the spot. Relatively large amounts of the substance were isolated by band chromatography of the extract (Sen, 1955).

To determine the growth-promoting activity of the substance, the paper chromatogram in the form of a strip was cut into small transverse segments. Each segment was then cut into smaller pieces, eluted in 2 ml. water and the eluate bioassayed by the pea root test (Leopold and Guernsey, 1953; Leopold, 1955; Sen, 1955). The increase in length was measured with a micrometer scale. When the per cent. increase in length over the control was plotted against the relative positions of the segments, a histogram of the type shown in Fig. 1 was obtained. For comparison, similar data obtained with strips of paper on which synthetic samples of indole acetic acid (IAA) and N-acetyl indoxyl (NAI) were run, are also included. It is clear that apart from IAA there is another growth-promoting substance in barley leaves.

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* From the Agricultural Experiment Station, Purdue University, Lafayette, Indiana, U.S.A. Presented at the Annual Meeting of the American Institute of Biological Sciences, Madison, Wisconsin, U.S.A., September, 1953.

Preliminary investigations indicated the R_f value of the growth substance, henceforth to be designated as growth substance X, from barley in isopropanol-ammonia-water (10: 1: 1) to be 0·87. From Sen and Leopold's (1954) data regarding the chromatographic behaviour of a large number of indole compounds, N-acetyl indoxyl appeared to have similar migration characteristics.

Comparative data regarding some of the chemical properties of the growth substance X from barley and N-acetyl indoxyl are shown in Table I. Some of the colour reactions are characteristic of indoxyl compounds. The growth substance X and N-acetyl indoxyl had practically the same R_f values in a number of solvents and gave identical colour reactions. Growth substance X, however, was not identical with N-acetyl indoxyl, since it did not produce a blue colour on treatment with NaOH (Table I).

TABLE I

Chemical properties of the growth substance X of barley leaves

	N-acetyl Indoxyl	"Auxin" from Barley
R_f value in isopropanol-ammonia-water	0·87	0·87
$FeCl_3$-$HClO_4$ Colour Test ..	Brown	Brown
HCl, Ninhydrin Colour Test	Red	Red
Thymol-$FeCl_3$-$HClO_4$ Colour Test	Red	Red
Proline Colour Test ..	No reaction	No reaction
1 N NaOH Colour Test ..	Blue	No Colour

DISCUSSION

Practically all the naturally occurring growth substances now definitely established are indole compounds. Critical analysis of the available data indicate that it is very doubtful that the di-sec-butyl cyclopentene derivatives, auxins *a* and *b*, are naturally occurring auxins (Thimann and Leopold, 1955). Apart from IAA, indole pyruvic acid, indole acetaldehyde, indole acetonitrile and the ethyl ester of IAA have been shown to occur in plants (Stowe and Thimann, 1953; Vlitos and Meudt, 1954; Larsen, 1944; Yamaki and Nakamura, 1952; Redemann *et al.*, 1951; Teubner, 1953; Bentley and Housley, 1952). The growth substance X described in this paper gives colour reactions

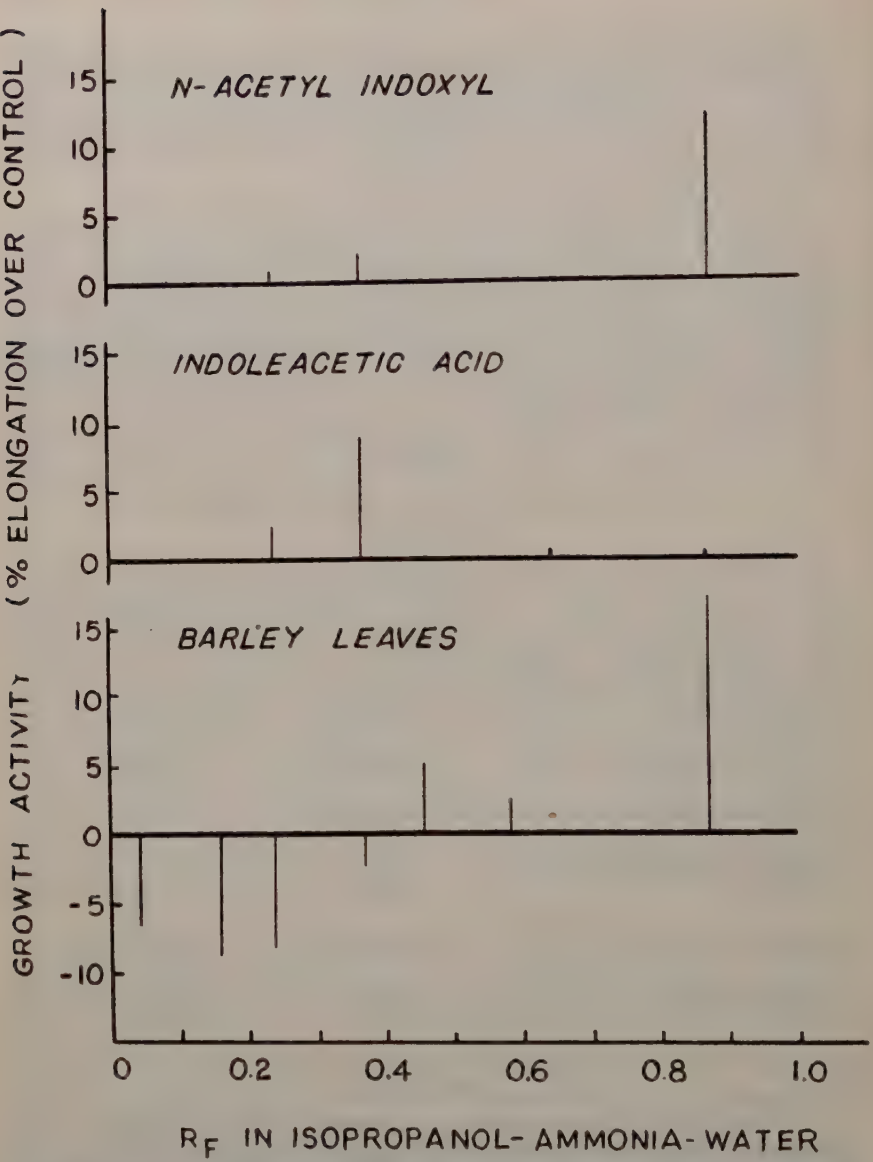

FIG. 1. A paper chromatographic analysis of the growth-regulating substances of barley leaves. The results obtained with indoleacetic acid and N-acetyl indoxyl are included for comparison.

characteristic of indole compounds. Stowe *et al.* (1956) have demonstrated that a number of phenolic compounds react with the Salkowski reagent, usually considered specific for indole compounds. The compound in question here, however, gave positive tests for indole compounds with a variety of reagents.

If the growth substance X is an indole compound it is highly probable that it is neutral in nature. The acid derivatives of indole have all low R_f values in isopropanol-ammonia-water (Sen and Leopold, 1954). Among the known naturally occurring neutral indole compounds, this growth substance is undoubtedly different from the ethyl ester of indoleacetic acid, indole acetaldehyde, indole aldehyde or indole acetonitrile since the R_f values and colour reactions characteristic of each individual do not agree with those of growth substance X. The colour reactions and R_f values of the compound and N-acetyl indoxyl are however very similar. Good *et al.* (1956) detected large amounts of indole acetamide in etiolated barley coleoptiles. But indole acetamide has a higher R_f value than that of N-acetyl indoxyl in the solvent system used. The colour reactions of N-acetyl indoxyl and indole acetamide are also different (Sen and Leopold, 1954). N-acetyl indoxyl however gives a blue colour with NaOH and it has not been demonstrated to occur in plants as yet. It is of interest to note in this connection that Beevers and French (1954) have obtained a crude preparation of an enzyme from a number of plant tissues, which include corn shoots and cucumber fruits, capable of oxidizing N-acetyl indoxyl to acetyl isatic acid. They suggested that N-acetyl indoxyl is not necessarily the naturally occurring substrate; probably a related compound serves as the substrate.

From Fig. 1, it is clear that apart from the growth substance X there is also an inhibitor of R_f value near about 0·20. A number of unidentified growth-regulating substances have been detected in a number of plant tissues (see Gordon, 1954; Sen, 1955) but the R_f values of the growth substance X or the inhibitor in barley do not agree with those of any one of them.

Summary

A growth-promoting substance of an R_f value 0·87 in isopropanol-ammonia-water (10 : 1 : 1) has been detected on the paper chromatogram of barley leaf extracts. The R_f values and some colour reactions of the substance are very similar to those of N-acetyl indoxyl but the two are not identical.

Indole acetic acid and a growth-inhibiting substance of an R_f value 0·20 in isopropanol-ammonia-water are also present.

Acknowledgement

The author is greatly indebted to Dr. A. C. Leopold for laboratory facilities, his keen interest and kind encouragement during the progress of the work.

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STUDIES IN THE FAMILY VITACEÆ

II. Floral Anatomy of *Vitis trifolia* Linn., *Vitis latifolia* Roxb. and *Vitis himalayana* Brandis

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Vitaceæ is a small family confined to tropical and sub-tropical regions. Except for a brief account by Saunders (1939), information regarding the floral anatomy of the family is meagre.

Material and Methods

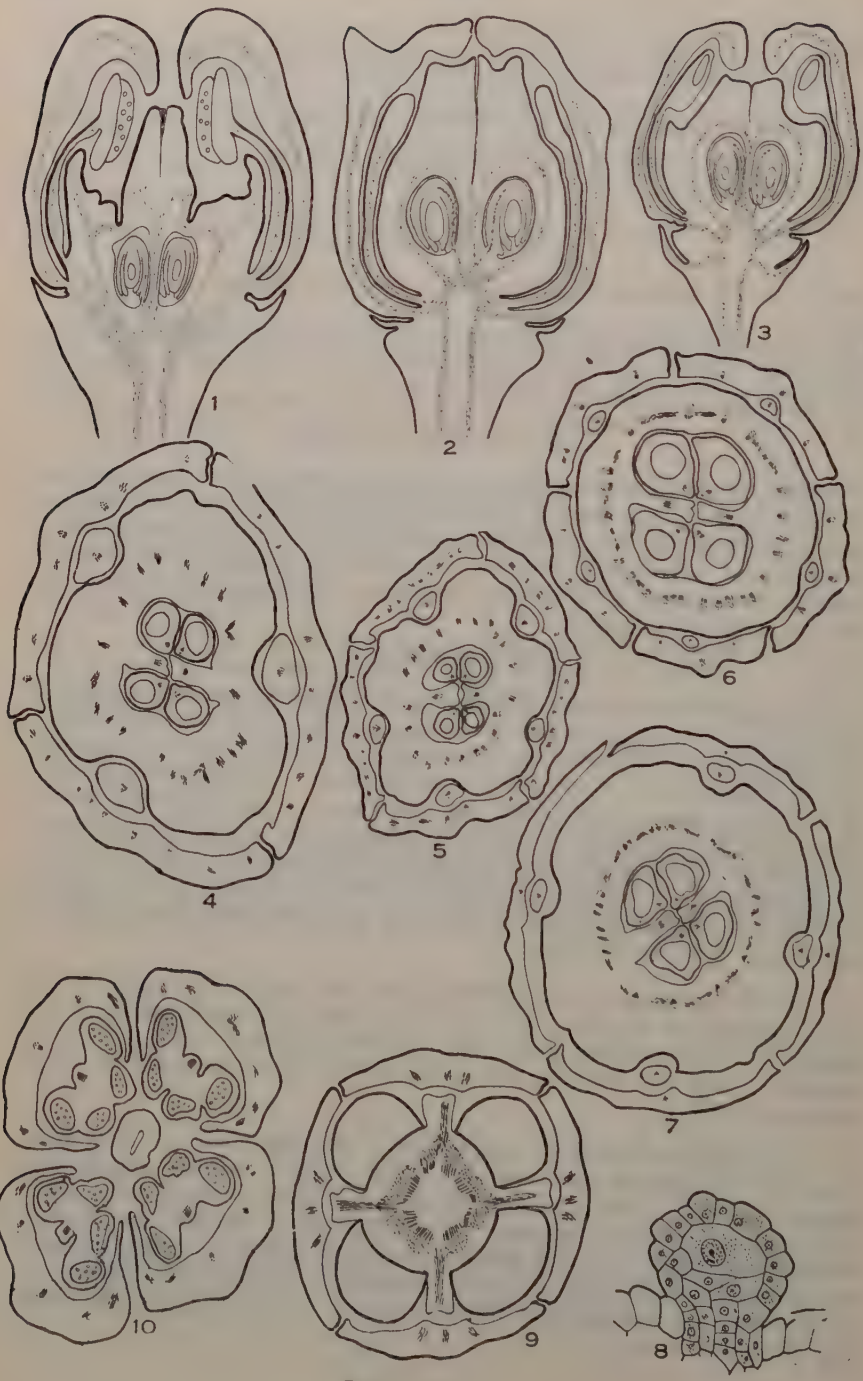
Buds, open flowers and fruits of *Vitis trifolia* and *V. latifolia* were collected locally and fixed in formalin-acetic-alcohol; *Vitis himalayana* was fixed at Naini Tal in 1954. Customary methods of dehydration, clearing and embedding were followed. Serial transverse and longitudinal sections were cut at 10–15 microns thickness, and stained in Gentian violet-Erythrosin.

Flower

Flowers are borne in dichasial cymes and are greenish yellow in *Vitis trifolia;* reddish brown in *V. himalayana* and *V. latifolia.* They are pedicellate, ebracteate in *V. trifolia* and *V. himalayana* and subsessile, bracteate and bracteolate in *V. latifolia.* Normally the flowers of *V. trifolia* and *V. himalayana* are tetramerous and sometimes pentamerous (Figs. 5 and 6). Trimerous flowers (Fig. 4) and flowers with three petals, five stamens and five petals, four stamens have been seen occasionally in *V. trifolia.* A pentamerous condition is the rule in *V. latifolia;* hexamerous flowers are rare and the tetramerous (Fig. 7) are found only as exceptions.

In all the species, multicellular hairs are found on sepals, petals and pedicels of flowers. In *V. trifolia* large spherical pearl glands borne on multicellular stalks are sometimes present (Fig. 8). The glandular cells are densely protoplasmic and are surrounded by large epidermal cells.

The calycine whorl is reduced to a circular rim. In *V. latifolia* there is an annular non-vascular tissue present between sepals and petals (Fig. 3). The boat-shaped, caducous petals, accommodate the antipetalous isomerous stamens. The filaments of stamens are broader below, tapering above and bearing dorsifixed anthers which are four-celled in *V. trifolia* (Fig. 10), and bicelled or occasionally tricelled in *V. latifolia.* Staminodes are found only in *V. himalayana* rarely they are partially fertile.



FIGS. 1–10

FIGS. 1–10. Floral anatomy of *Vitis* species. Fig. 1. *Vitis trifolia*, l.s. flower. Fig. 2. *V. himalayana*, l.s. flower. Fig. 3. *V. latifolia*, l.s. flower. Fig. 4. *V. trifolia*, c.s. trimerous flower. Fig. 5. C.s. pentamerous flower. Fig. 6. *V. himalayana*, c.s. pentamerous flower. Fig. 7. *V. latifolia*, c.s. tetramerous flower. Fig. 8. Pearl gland. Fig. 9. *V. himalayana* c.s., flower showing deeply lobed disc and traces to petals and stamens. Fig. 10. *V. trifolia*, c.s. flower showing four anther lobes. Figs. 1, 2, 3, 5, ×5 and others, ×9.

A prominent disc is present, confluent with the ovary wall. It is deeply lobed at the base in *V. himalayana* (Fig. 9), circular and lobed in *V. trifolia* and angular in *V. latifolia*. At a higher level it becomes more or less circular and lobed. Its epidermis is glandular and is made up of parenchymatous tissue in which large raphides occur in enlarged cells, called raphide sacs. Raphides are present in other floral organs also. Gynœcium is bicarpellary, syncarpous; the ovary is bilocular with carpellary margins incompletely fused in the centre, and with two ovules in each locule. The style is massive in *V. trifolia* (Fig. 1) but almost absent in *V. latifolia* and *V. himalayana* (Figs. 2 and 3).

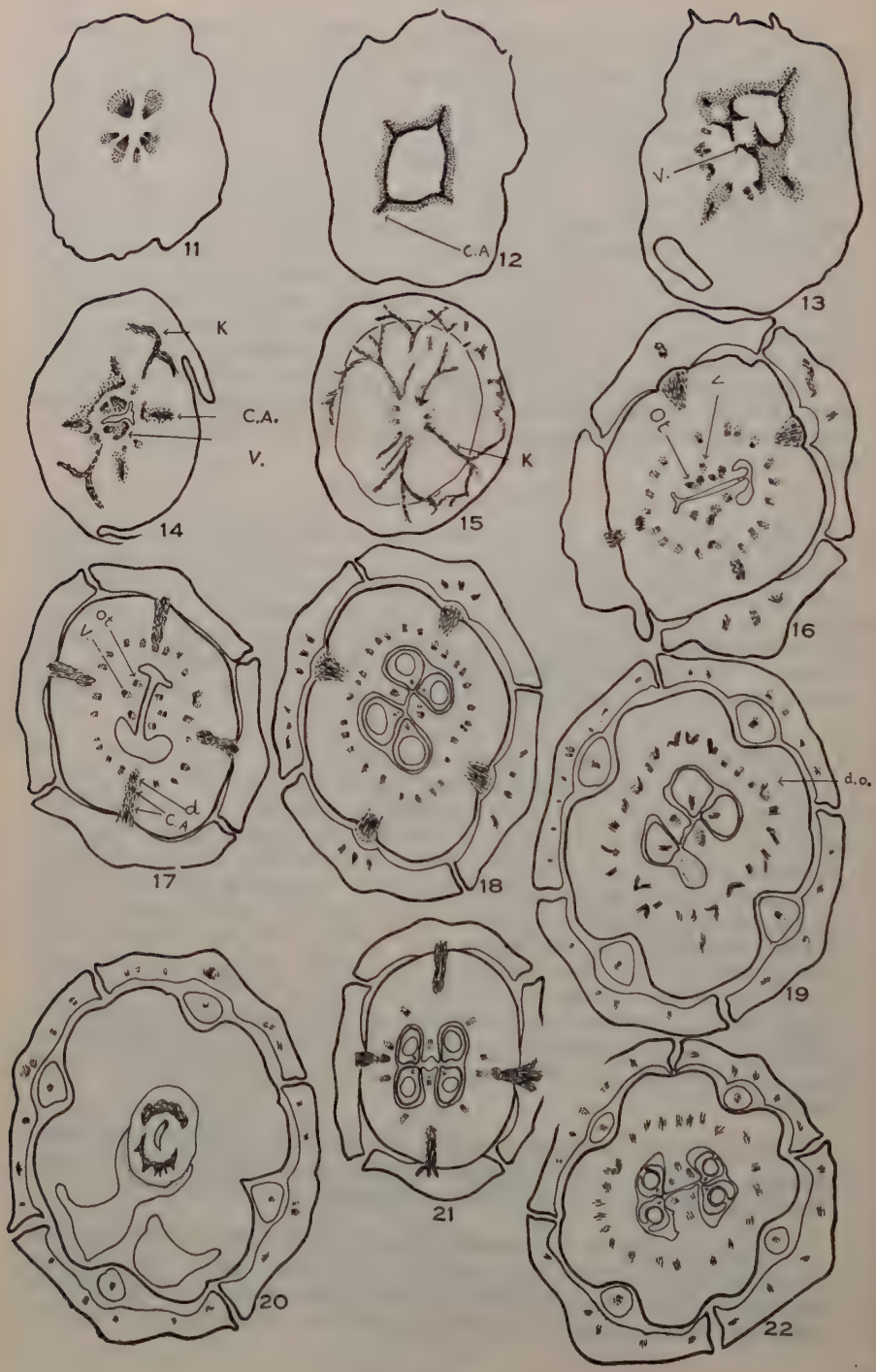
VASCULAR ANATOMY

The peduncle in *V. latifolia* shows a ring of collateral endarch bundles from which a trace is given off to the bracts which soon branches into three. Next the traces for the pedicel depart from the main stele. From the stele of the pedicel, traces for the bracteoles are given out laterally, which may either persist or not in each bracteole. The pedicel shows a dissected siphonostele of about six to eight bundles (Fig. 11) which higher up branch radially and fuse to form a continuous stele (Fig. 12).

The rim-like calycine whorl is non-vascular in *V. trifolia* and *V. himalayana*. In exceptional cases it was observed in these species that traces for the sepals arise from the stele, though they do not enter them (Fig. 14). A similar non-vascular calycine whorl has also been reported in some members of Oleaceæ (Joshi and Fotidar, 1940). However, in *V. latifolia* sepals are vascularised (Fig. 15) getting five sepal traces given out from the receptacular stele. Some of them branch immediately into three distinct traces, one median and two laterals, while others divide only when entering the sepals. In any case the sepal traces repeatedly branch in the calycine ring (*cf.* Berkley, 1953). The origin of sepal-median and marginals as one trace indicates that the sepals are fused congenitally. The gaps formed by the departure of the calycine traces are soon bridged over and a continuous stele is again formed.

Before giving out traces to petals, stamens and carpels, the receptacle expands and the stele becomes angular—quadrangular in *V. trifolia* and *V. himalayana* (Fig. 12) and pentangular in *V. latifolia*.

Corresponding to the number of petals and stamens, stout vascular chords swing out from the angles of the main stele. These divide tangentially, into an outer and an inner; the inner ones opposite the loculi behave as carpellary dorsals while the corresponding traces at



FIGS. 11–22

FIGS. 11–22. Floral anatomy of *Vitis trifolia* and *V. latifolia* (Fig. 15 only). Fig. 11. *V. trifolia*, pedicel with dissected siphonostele. Fig. 12. C.s. receptacle showing rectangular siphonostele and conjoint traces for petals and stamens. Fig. 13. C.s. flower showing organisation of ventrals. Fig. 14. Same, note two sepaline traces. Fig. 15. *V. latifolia*, c.s. flower with sepaline supply. Fig. 16. *V. trifolia* ovular traces dividing. Fig. 17. C.s. flower showing conjoint traces for petals and stamens; note carpellary dorsals. Fig. 18. C.s. flower showing bundles in petals and traces to stamens; note disc and ovular supply. Fig. 19. C.s. flower, showing branched dorsals and bundles of disc. Fig. 20. C.s. flower showing branched ventrals joined with dorsals. Fig. 21. C.s. flower showing origin of dorsals and antisepalous disc bundles. Fig. 22. C.s. flower showing antisepalous loculi.

c.a., petaline and staminal traces; *d.*, carpellary dorsal; *d.o.*, fused disc and ovary wall; *k.*, sepaline trace; *o.t.*, ovular trace; *v.*, carpellary ventral.

Fig. 21, ×5. Other Figs. ×9.

the septal radii remain in the disc and branch repeatedly or fade away (Figs. 13, 17). The outer traces again split up tengentially; of these the peripheral ones pass into the petals and divide (Figs. 17, 18) and the inner ones supply the staminal whorl (Fig. 18). Saunders (1939) reports that in the allied family Rhamnaceæ the traces for the petals and the stamens arise conjointly. *Tetracentron* also shows the origin of stamen and perianth trace as one bundle. It further shows incipient adnation of stamen and perianth to the ovary (Eames, 1931). In one case of *V. trifolia* it was observed that in the position of the carpellary dorsals, two traces originate opposite one loculus and three opposite the other. The remaining stele organises into four antisepalous disc bundles (Fig. 21), these, along with the dorsals divide and redivide in the disc. In *V. himalayana* the carpellary dorsals arise directly from the main stele.

An important deviation was observed in the orientation of loculi in the gynœcium of *V. trifolia* and *V. latifolia* (Figs. 22, 7). In these the loculi are antisepalous and not antipetalous which is the normal condition (Fig. 18). This probably shows that the bicarpellary gynœcium with two loculi has been derived by reduction from an original polycarpellary, multilocular gynœcium. Gynœcia with three and four loculi in *V. latifolia* are of significance in this connection. The dorsals reach up to the base of the style in *V. trifolia* (Fig. 1) while in *V. latifolia* and *V. himalayana* they fall short at a lower level (Figs. 2 and 3).

As the traces diverge out for petals and stamens in *V. trifolia* and *V. latifolia*, two traces originate from the stele antero-posteriorly and opposite to each other; they travel inwards, unite and become inverted (Fig. 13). Each divides into three bundles (Fig. 17), the central one is the ventral and the other two are the ovular traces (Fig. 18). In *V. himalayana* on the other hand, the ventrals organise only after vascular supply to the petals and stamens. Occasionally in *V. trifolia* ovular traces of a side divide (Fig. 16) and one of its branches enters the ovule and the other is arrested in the placenta. Thus the ovular supply, instead of functioning directly, may function as the placental bundle which in turn supplies the ovules. Later as the ventrals ascend, the ventral of the other side also divides into three. In some cases the ventrals immediately after supplying the ovules, again divide into three

bundles and these probably represent the supply to the ovules that no longer exist. Berkeley (1953) believes that they supply the septum in *Euonymus japonica*. Exceptionally in *V. trifolia* the ventrals and the placental bundles originate separately from the main stele and the ovular traces originate from the placental bundles. The ventrals, in the style branch, become normally oriented and join the branches of the dorsals (Fig. 20) in *V. trifolia*; in the other two species, since the style is absent this happens in the apical region of the disc.

The disc is completely fused with the ovary wall. It is supplied by the enlarged bundles of the axis. The dorsals get mixed up with the receptacular bundles and both branch in the disc (Fig. 19).

Discussion

Eames (1929) is of the view that the organs, when lost externally, the 'stubs' of their vascular supply prove their former existence. This is the 'doctrine of the conservatism of the vascular bundles'. In case of *V. trifolia* and *V. himalayana* though the sepaline vascular supply is lacking, the reduced sepals still exits in the form of a rim. In this connection according to Arber (1933) 'an organ which retains some traces of its external form, may yet show a complete lack of vascular tissue'. It thus becomes clear that we have no alternative but to discard the doctrine of the conservatism of the vascular bundles.

It is really difficult to interpret the morphological nature of the disc since it is congenitally fused with the ovary wall. It appears to be receptacular since it receives an elaborate vascular supply from the main stele. The carpellary dorsals are found along with the receptacular bundles and are indistinguishable from one another.

The gynœcium is hypogynous or slightly perigynous. The flower is probably heading towards epigyny because in all these species not only the petaline and the staminal traces originate conjointly but also the carpellary dorsals emerge fused with them in *V. trifolia* and *V. latifolia*.

Anatomically the gynœcium has a parietal placentation in the three species of *Vitis* investigated. Since the margins of the carpels never fuse completely in the centre, the ovary is unilocular. The ovules are borne on the fused margins of adjacent carpels and derive their vascular supply from their ventrals.

Summary

Floral anatomy of *V. trifolia*, *V. latifolia* and *V. himalayana* has been studied comparatively. Pearl glands occur in *V. trifolia*. Sepals are reduced to a rim and are vascularised in *V. latifolia* only; traces for petals, stamens and carpellary dorsals arise conjointly in *V. trifolia* and *V. latifolia*. In *V. himalayana*, however, the dorsals arise independently. Disc is congenitally confluent with the ovary wall and is receptacular. The placentation is parietal.

ACKNOWLEDGEMENTS

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DEVELOPMENT OF THE EMBRYO IN *HYPOXIS AUREA* LOUR

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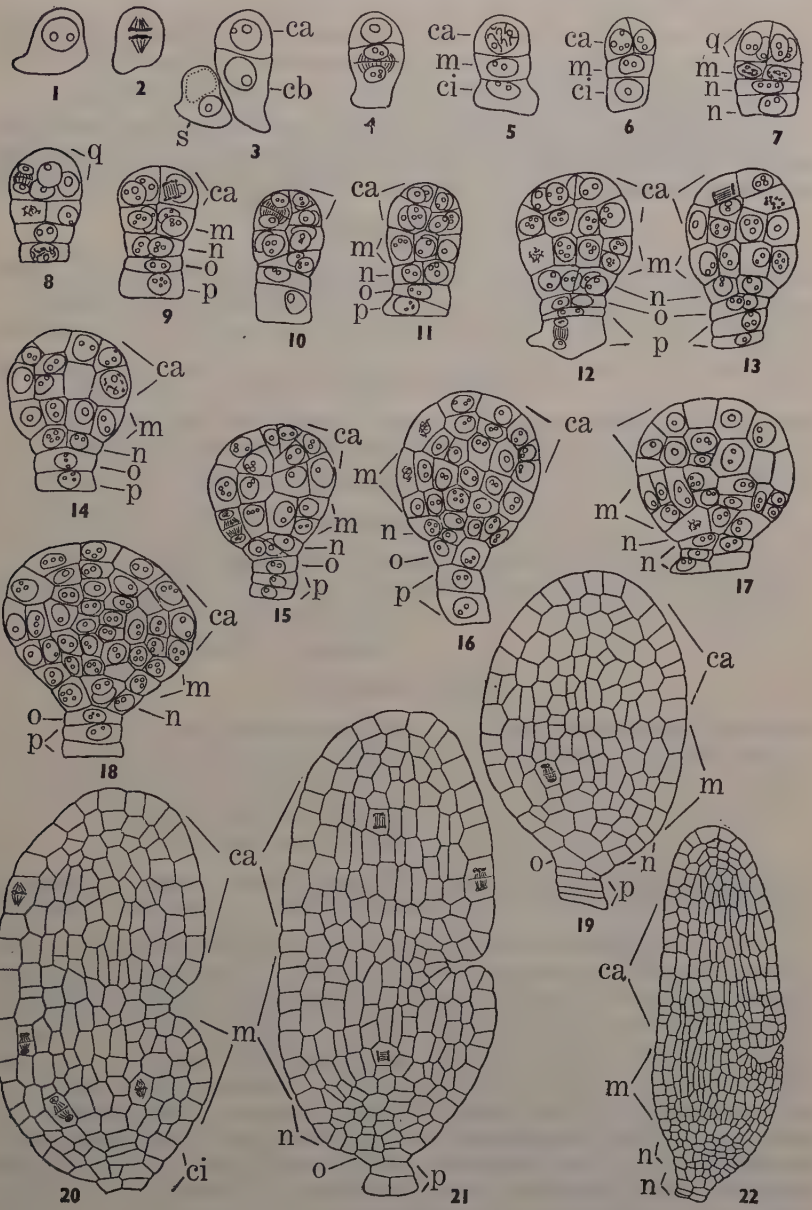
Introduction

Hypoxis aurea belongs to tribe Hypoxideæ of the Amaryllidaceæ. Stenar (1925) recorded the salient features of *Hypoxis* in his embryological studies of the Amaryllidaceæ. In her studies on the development of the ovule and the seed in the Hypoxideæ De Vos (1948, 1949) reported the development of female gametophyte, endosperm, embryo and seed coat structure of *Ianthe*, *Pauridia* and *Forbesia*. In these genera the first four cells of the embryo are arranged in a T-shaped manner and their further development conforms to the Asterad type, the fully developed embryo remains undifferentiated in the mature seed. Crété (1951) traced the development of embryo in *Hippeastrum vittatum*. The cleavage of quadrants in this plant takes place generally by anticlinal walls separating eight cells arranged in the same plane. The embryogenesis conforms to the Megarchetype I in the First Period. The present paper deals with the development of embryo in *Hypoxis aurea*.

The material for the investigation was collected in Narasimharajapura, Mysore State, and fixed in formalin-acetic-alcohol. Customary methods were followed during dehydration and embedding. Sections were cut at a thickness of 8–14 microns and stained in iron-alum Hæmatoxylin.

Observations

The zygote divides transversely to form the two-celled proembryo (Figs. 1–3). The basal cell *cb* undergoes a similar division resulting in cells *m* and *ci* (Figs. 4–5). The terminal cell *ca* next divides vertically producing two juxtaposed cells (Fig. 6). The first tetrad therefore conforms to the A_2 category in the embryogenic classification of Souèges. A similar primary tetrad of the embryo has been recorded in *Hypoxis decumbens* (Stenar, 1925), *Ianthe*, *Pauridia* and *Forbesia* (De Vos, 1948, 1949) and *Hippeastrum vittatum* (Crété, 1951). The two terminal cells of the tetrad soon undergo a vertical division at right angles to the first and organise the quadrants *q*. A transverse division in *ci* produces two superposed cells *n* and *n'* (Fig. 7). The quadrant cells then undergo a transverse division forming two tiers of four cells each and the two cells constituting *m* undergo another vertical division at right angles to the first producing four cells. Simultaneously with these divisions cell *n* divides longitudinally and a transverse division in *n'* results in cells *o* and *p* (Figs. 8–11). Now periclinal and anticlinal walls are laid



FIGS. 1–22. *Hypoxis aurea* Lour. Stages in embryo development (*S*, synergid). Figs. 1–18, ×386; Figs. 19–21, ×326; Fig. 22, ×194.

down in the two tiers of cells derived from *q* and in the cells of *m* which finally contribute to the formation of the terminal cotyledon and the hypocotyledonary part *plus* the stem tip respectively (Figs. 12–22).

Meanwhile the two cells of *n* undergo vertical and transverse divisions and contribute to the initials of the root cortex and root cap. Cells *o* and *p* divide further and give rise to a short suspensor.

The following recapitulatory tables of the laws of embryo development, as adopted by Souèges for the analysis of embryogenesis summarise the course of development in *Hypoxis aurea.*

First generation

Proembryo of two cells arranged in two tiers (as in Fig. 2)	*ca* which gives rise to *pco* *cb* which gives rise to *phy* + *pvt* + *icc* + *iec* + *co* + *s*

Second generation (tetrad)

Proembryo with four cells arranged in three tiers (as in Fig. 6)	*q* which gives rise to *pco* *m* which gives rise to *phy* + *pvt* + *icc* *ci* which gives rise to *iec* + *co* + *s*

Third generation

Proembryo with eight cells arranged in four tiers (as in Fig. 7)	*q* which gives rise to *pco* *m* which gives rise to *phy* + *pvt* + *icc* *n* which gives rise to *iec* + *co* *n'* which gives rise to *s*

Fourth generation

Proembryo with sixteen cells arranged in five tiers (as in Fig. 10)	*q* which gives rise to *pco* *m* which gives rise to *phy* + *pvt* + *icc* *n* which gives rise to *iec* + *co* *o* which gives rise to *s* *p* which gives rise to *s*

(*pco*, cotyledonary part; *pvt*, stem apex; *phy*, hypocotyl part; *icc*, initials of central cylinder of root; *iec*, initials of epidermis of root; *co*, root *cap*; *s*, suspensor)

The Amaryllidaceæ and Liliaceæ are connected together by the same embryonic type except for variations of secondary importance. *Hypoxis* presents a type of embryo development closely comparable to *Anthericum ramosum* (Souèges, 1918). In this species the divisions in the quadrants are transverse separating four superior and four inferior octants; *co* arises likewise from *n*. *Hippeastrum* (Crété, 1951), on the other hand, approaches *Muscari comosum* which Souèges has chosen as a type representative of Megarchetype I. In these species anticlinal walls in the quadrants result in eight cells arranged in the same plane and thus there is no formation of octants.

Summary

The development of embryo in *Hypoxis aurea* Lour has been described in detail. It corresponds to Megarchetype I, First Period, in the embryogenic system of Souèges. The divisions in the quadrants are transverse, separating four superior and four inferior octants. The

root cap arises from cell *n*. The embryo in the mature seed is well differentiated.

We are highly thankful to Professor K. N. Narayan for guidance, Professor P. Maheshwari, University of Delhi, for loan of literature and Professor P. Créte, Faculté de Pharmacie, Laboratoire de Botanique, Paris, for very helpful suggestions.

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ON A COLLECTION OF LIVERWORTS FROM YERCAUD, SOUTH INDIA*

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Introduction

The present paper deals with some Liverworts collected by one of us (A. R. Rao) from the hill station Yercaud, situated on the Shevaroy Hills near Salem, South India. A preliminary note on these specimens was communicated to the Indian Science Congress, Delhi (Rao, 1946). A detailed investigation of these liverworts is now being carried out and a part of the results obtained are included in the present paper.

Yercaud, from where the collections were made, is situated at an altitude of 4828′ above sea-level. The hills situated in the middle of the Southern plateau, have a mild and pleasant climate and receive both the S.-W. and N.-E. Monsoons, with an average rainfall of 65–70 inches, which is double that of the plains. The temperature is about 14° less than that of the plains and the humidity during any particular season is fairly constant. The highly humid conditions favour a luxuriant hepatic vegetation. Extensive coffee plantations are distributed over these areas at this altitude. *Grevillea robusta* is cultivated widely in these estates to provide the necessary shade for the coffee plants. Pears and oranges are also widely cultivated. The liverworts described in this paper were mostly collected from the barks of some of the trees mentioned above, and also from the moist humus covering the rocks occurring amidst these plantations.

The collections were made on two different occasions but both in the month of June, 1945, just when the monsoon had broken out. This season, however, is most unsuitable for collections as reproductive structures generally appear much later. Consequently, most of the species had to be described from sterile specimens. Subsequent attempts to collect fertile materials were unsuccessful.

The liverworts described in this paper are being reported for the first time from this locality. In fact, the cryptogamic vegetation of these hills, so far as we are aware at least, does not seem to have been seriously noticed so far. A thorough search in this locality at a more favourable season will undoubtedly reveal many more species of liverworts. But even as it is, this meagre collection promises to contain several hitherto unrecorded species from South India. The present paper deals with only a part of the collection and referred to the families

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Lejeuneaceæ and *Plagiochilaceæ*. The remaining part will be published in a separate paper.

As already stated above, the provisional specific identification has been based mostly on the vegetative characters. But even these vegetative features have been fully described because they show some important differences. These differences may be just unimportant vegetative variations of ecological nature, or they may turn out to be important specific differences which might be further corroborated when fertile organs are discovered.

It is noteworthy that all the species except *Plagiochila* sp. and *Archilejeunea* sp. described in this paper, are found in a collection made from Kudure Mukh in South India by Pfleiderer and described by Pandé, Bharadwaj and Ram Udar (1949) and Pandé and Ram Udar (1950).

Material and Method

The plants collected were packed dry in paper envelopes. For investigation this dry material was first soaked in warm water to ensure proper stretching of the various parts, and then very gradually dehydrated in grades of ethyl alcohol and finally preserved in 90% alcohol and glycerine (mixed in equal proportions). All the specimens described in this paper are deposited in the Lucknow University Hepatic Herbarium.

Description

LEJEUNEACEÆ

1. *Archilejeunea* sp.

(Figs. 1–3)

Plants: Sterile, brown green, growing in depressed mats; *Leaves:* Imbricate, entire and *rounded at the apex*, strongly curved outwardly; *lobes widely spreading*, *lobule* ovate, margin free, sometimes revolute at the base *with one or two* teeth on the top, *trigones* conspicuous. *Underleaves:* Distant, appressed on the stem, broadly orbicular to obovate, *rounded at the apex*.

Locality.—Yercaud. No. 4454. Coll. A. R. Rao.

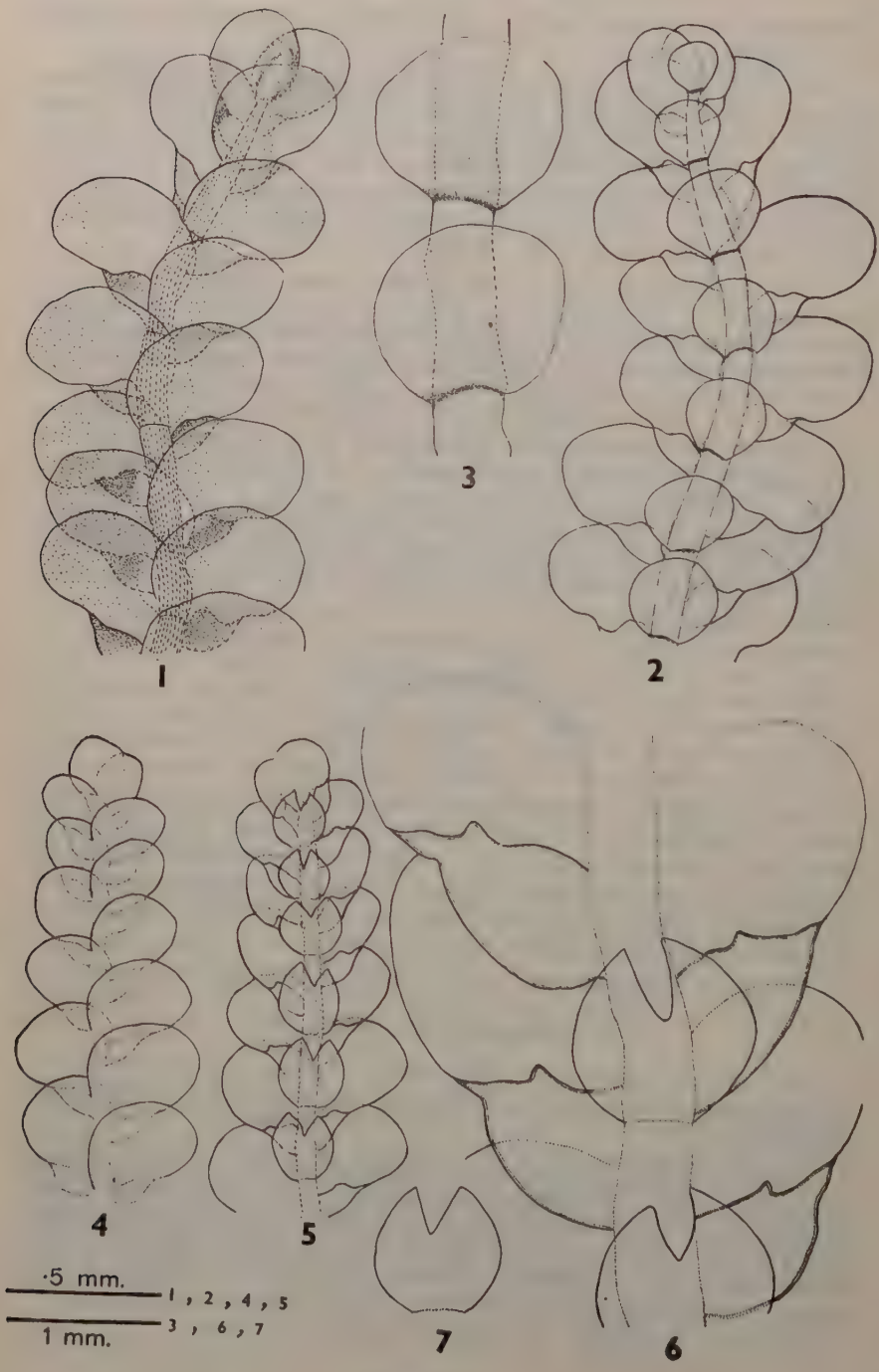
2. *Harpalejeunea indica* St.

(Figs. 4–7)

Our plants are similar to *H. indica* St. found in the Pfleiderer's collection.

Plants: Sterile, pale green, sparingly branched; *Leaves:* Imbricate, *lobes* widely spreading, ovate, margin entire, *apex bluntly acute*, *lobule ovoid*, *strongly inflated*, *apical tooth blunt*, cells of the lobe averaging $14\,\mu \times 12\,\mu$ at the apex, $20 \cdot 7\,\mu \times 16\,\mu$ in the middle and $31\,\mu \times 29\,\mu$ at the base, walls thickened, *trigones* present. *Underleaves:* Large, distant, bifid almost upto the middle, $\cdot 23 \times \cdot 21$ mm.

Locality.—Yercaud. No. 4456. Coll. A. R. Rao.



FIGS. 1–7

TEXT-FIGS. 1–3. *Archilejeunea* sp. Fig. 1. Dorsal view of the plant. Fig. 2. Ventral view of the plant. Fig. 3. Ventral view to show amphigastrium.

TEXT-FIGS. 4–7. *Harpalejeunea indica* St. Fig. 4. Dorsal view of the plant. Fig. 5. Ventral view of the plant. Fig. 6. Ventral view to show amphigastrium and lobule. Fig. 7. An amphigastrium.

3. *Eulejeunea* sp.

(Figs. 8 and 9)

The plant shows a close resemblance to an unidentified *Lejeunea* described by Pandé and Misra (1942) from Gersoppa Falls in South India. Specific identification has been very difficult in view of the scarcity of specimens in the collection and also the absence of the fertile organs.

Plants: Sterile, delicate and thin, *Stem* sparingly branched. *Leaves:* Sessile, more or less covering the stem, ovato-rotundate, alternate, incubous, *apex rounded* and margin entire, *Cells* averaging on apex $12\,\mu \times 14\,\mu$, in the middle $27\,\mu \times 22\,\mu$ and at the base $45\,\mu \times 30\,\mu$; lobules long and inflated, tooth at the apex, trigones of the cells distinct but the walls are thin. *Underleaves:* Big, broader than the stem, transversely inserted, bifid.

Locality.—Yercaud. No. 4454. Coll. A. R. Rao.

4. *Ptychocoleus fertilis* (R. Bl. N.) Trev.

(Figs. 10, 11)

Plants: Sterile, in dark green depressed mats, *Stem* irregularly pinnate, branches spreading and squarrose. *Leaves:* Broadly ovate, slightly falcate, arching partially across the axis, rounded at apex, margin entire, strongly outwardly curved from the antical base to the apex; *Lobule* ovate, 0·39 mm. × 0·16 mm., apical tooth present. *Trigones* conspicuous. *Underleaves:* Slightly overlapping at places, convex at the apex, broadly ovate, margin entire.

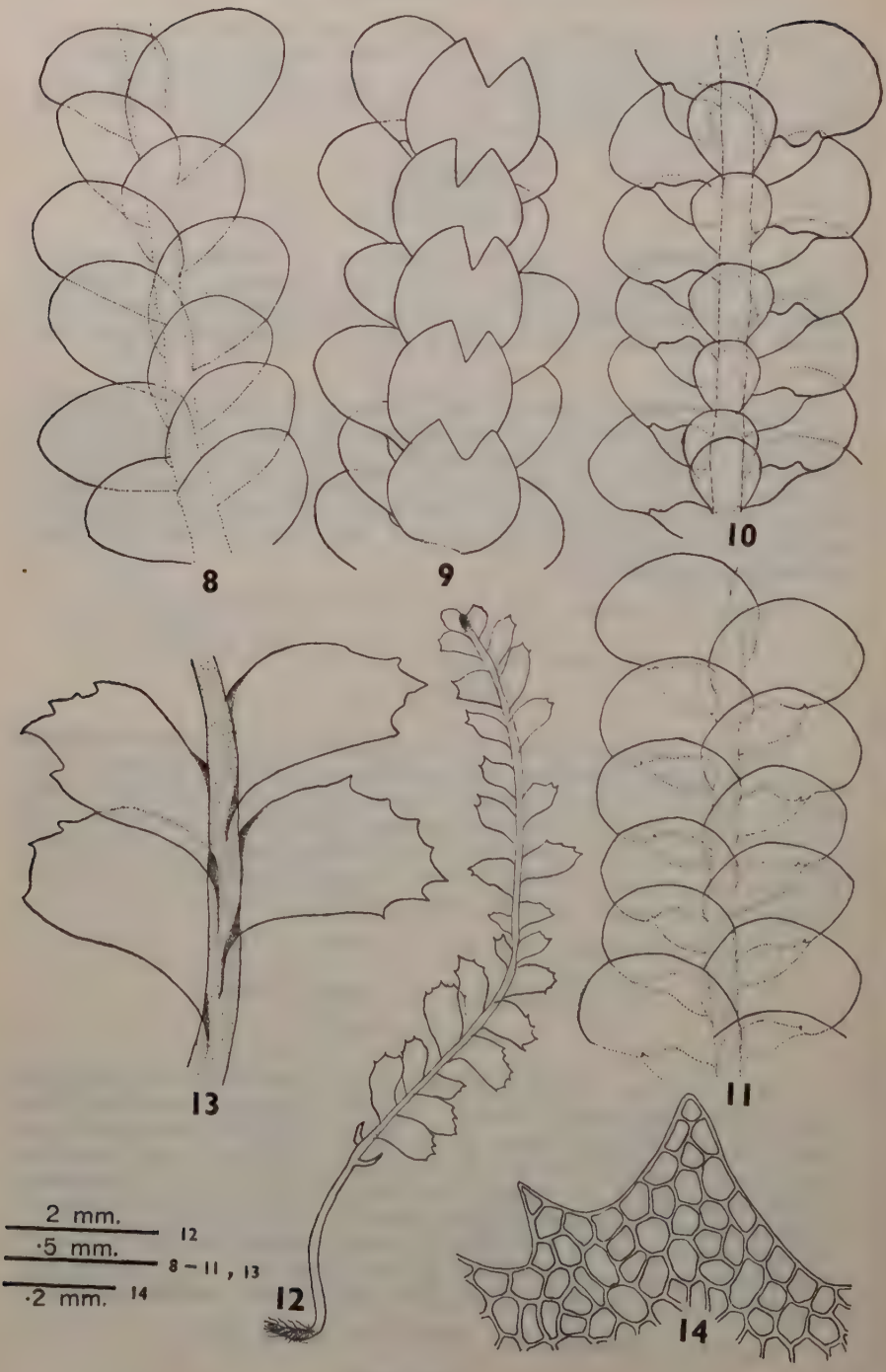
Locality.—Yercaud. No. 4457. Coll. A. R. Rao.

5. *Thysananthus polymorphus* Sande

(Figs. 15, 16)

Plants: Large, fertile, dicœcious, growing usually in wide depressed mats. *Stem* irregularly pinnate. *Leaves:* densely imbricate, lobes ovate, margin toothed, apical tooth largest, leaf cells averaging at the apex $8\,\mu \times 9\,\mu$ and $21\,\mu \times 14\,\mu$ in the middle. *Lobules* ovate, decurrent at the base, small and poorly developed. *Underleaves:* Contiguous, broadly obovate-orbicular, slightly crenulate or denticulate at the apex. *Female inflorescence* on a branch; *Perianth* obovate, big, almost rounded above and abruptly narrowed at the base, more or less compressed on the sides, and at the apex, shows five keels clearly. *Andrœcium* absent.

Locality.—Yercaud. No. 4457. Coll. A. R. Rao.

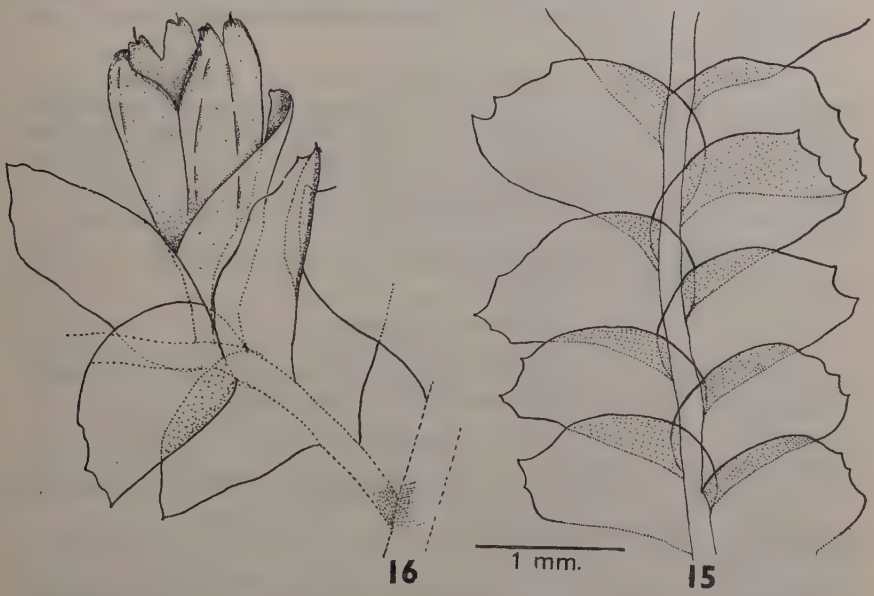


FIGS. 8–14

TEXT-FIGS. 8–9. *Eulejeunea* sp. Fig. 8. Dorsal view of the plant. Fig. 9. Ventral view of the plant.

TEXT-FIGS. 10–11. *Ptychocoleus fertilis* (R. Bl. N.) Trev. Fig. 10. Dorsal view of the plant. Fig. 11. Ventral view of the plant.

TEXT-FIGS. 12–14. *Plagiochila* sp. Fig. 12. Entire plant. Fig. 13. A part of the plant. Fig. 14. Cells at the apex.



TEXT-FIGS. 15–16. *Thysananthus polymorphus* Sande. Fig. 15. Dorsal view of the plant. Fig. 16. Female branch.

PLAGIOCHILACEÆ

6. *Plagiochila* sp.

(Figs. 12–14)

The plants referred to this genus were found growing on rocks in shady habitats and are quite different from those described by Pandé *et al.* (1949, 1950) from the Pfleiderer's collection. Chopra (1938) has not described any species of *Plagiochila* from South India although he has referred to the occurrence of this genus. The specific identification on the basis of purely vegetative parts seems rather difficult. Following up Carl's excellent monograph (1931) we are able to refer this species to Section *Euplagiochilæ*. More materials and in advanced stages are necessary before the species can be identified. A description, however, of the vegetative characters is given below:

Stems: Slender, branching irregularly, arising from a creeping nearly leafless rhizome-like stem with dense rhizoids over it, rhizoids almost absent in ascending stems. *Leaves:* obliquely inserted, irregularly disposed, small and distant below, larger and expanding above,

the postical margin broadly expanded and strongly arched above the base, trigones distinct.

Locality.—Yercaud. No. 4456. Coll. A. R. Rao.

Summary

Detailed examination of a part of a liverwort collection made from Yercaud, a hill station on the Shevaroy Hills in South India, shows the following species:—

Archilejeunea sp., *Harpalejeunia indica* St.. *Eulejeunea* sp., *Ptychocoleus fertilis* (R. Bl. N.) Trev., *Thysananthus polymorphus* Sande and *Plagiochila* sp. All but two of these species have been found in Pfleiderer's collections made from Kudure Mukh in South India and one in Pandé's collection from Gersoppa Falls. Detailed description of the specimens, which are mostly sterile, and their habitats are given.

This collection perhaps constitutes the first systematic record of the liverwort flora of this locality.

Acknowledgments

The authors are very grateful to Dr. S. K. Pandé for his valuable criticism and advice in the preparation of this paper.

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EPIPHYLLOUS LIVERWORTS OF INDIA AND CEYLON—II*

By S. K. Pandé, K. P. Srivastava‡ and S. Ahmad

Lucknow University

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Introduction

In an earlier article on epiphyllous liverworts, Pandé and Misra (1943) published an illustrated account of five species of this group, *viz.*, *Rectolejeunea aloba* (Sande Lac.) St., *Leptolejeunea himalayensis* Pandé et Misra, *Cololejeunea himalayensis* Pandé et Misra, *Cololejeunea hispidissima* (St.) Herz. and *Leptocolea lanciloba* St. This stimulated further interest in a study of these plants and Pandé and Ahmad (1942, 1943), on the basis of preliminary examination of collections made by Pandé from several localities (Pedros Peak, Ceylon, 1939; Gersoppa Falls, Western Ghats, 1940; Jorpokhari and Rimbic, Eastern Himalayas, 1941) reported twelve more species from the country. These are *Radula protensa* Lindberg, *Frullania* sp., *Drepanolejeunea foliicola* Horikawa, *Drepanolejeunea* sp., *Leptolejeunea schiffneri* St., *Lejeunea* sp., *Microlejeunea* sp. I, *Microlejeunea* sp. II, *Tæniolejeunea pseudofloccosa* (Horikawa) Hattori, *Tæniolejeunea peraffinis* (Schffn.) Zwickel, *Aphanolejeunea* sp. I and *Aphanolejeunea* sp. II.

Kachroo (1951) listed two epiphyllous liverworts, *Cololejeunea venusta* (Sande Lac.) Schffn. and *Leptocolea lanciloba* from the neighbourhood of Gauhati in Assam, describing some taxonomic details of these.

In the course of a botanical tour of the Western Ghats in 1950, Pandé and Srivastava made an extensive collection of epiphyllous liverworts from Agumbe, 2,500 ft. (Western Ghats), and Gersoppa Falls, 4,000 ft. (Western Ghats). A preliminary study of these collections has shown that Agumbe is fairly rich in epiphyllous liverworts, and more than a dozen species have so far been identified from this locality. Such a rich growth of epiphyllous liverworts is undoubtedly due to the fact that Agumbe is very humid; its annual rainfall being about 327 inches.

The total number of this interesting group of liverworts, so far recorded from India, is more than three dozen species, distributed as shown in the accompanying table.

The present paper gives the description of four species of epiphyllous liverworts, *i.e.*, (1) *Tæniolejeunea peraffinis* (Schffn.) Zwickel, (2) *Tæniolejeunea pseudofloccosa* (Horikawa) Hattori, (3) *Leptolejeunea schiffneri*

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St., and (4) *Drepanolejeunea foliicola* Horikawa. The species have been described earlier by various hepaticologists, and our studies are on the whole, in agreement with them. However, as detailed illustrated accounts of these are not easily accessible to students of Indian Hepatics an attempt has been made to describe them from Indian specimens. Besides, it has now been possible for the authors to supplement the description of some of the species which were so far inadequately described.

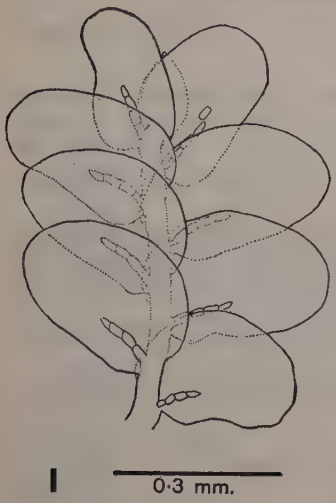
The observations recorded are based on specimens collected by Pandé from Rimbic and Jorpokhari (Eastern Himalayas), Gersoppa Falls (Western Ghats), Pedros Peak (Ceylon), and Pandé and Srivastava from Gersoppa Falls (Western Ghats) and Agumbe (Western Ghats).

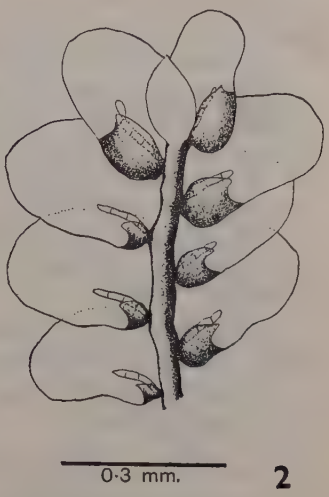
Description

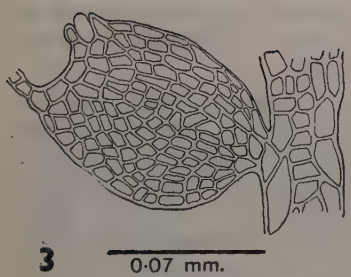
1. *Tæniolejeunea peraffinis* (Schffn.) Zwickel

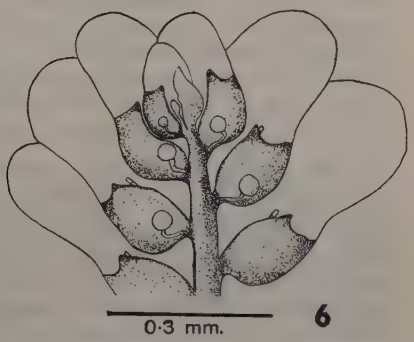
Tæniolejeunea was segregated as a new genus of Hepaticæ by Zwickel (1933) to include those species of *Leptocolea* Evans and *Cololejeunea* Spruce, in the restricted sense (*Physocolea* St.), which possess a characteristic seriate band of ocelli in their leaf. The genus was later studied by Hattori (1941) according to whom it differs from *Leptocolea* in (i) the smaller size of its plants, (ii) thicker cell walls, often becoming trabeculate, and larger trigones, (iii) ocelli being most often present and (iv) papillæ always present. In distinguishing the two genera, Hattori (1941) places greatest reliance on the characteristics, second and fourth. As at present known (Zwickel, 1933; Hattori, 1941) the genus includes nine tropical and subtropical species, one of which is *T. peraffinis*, the liverwort under consideration, originally described by Schiffner (1893) from Java as a new species of *Cololejeunea*. While proposing the species Schiffner (1893) did not altogether exclude the possibility of its being a variety (variety *major*) of *Cololejeunea floccosa* (L. et L.) Schffn. (= *Leptocolea floccosa* St.), a liverwort known from the same region. Later, when Evans (1911) segregated *Leptocolea* and *Aphanolejeunea* as independent genera from *Cololejeunea*, this liverwort was assigned to the original genus (*i.e.*, *Cololejeunea*). Stephani (1912–17) includes it under *Physocolea*. Herzog (1931) ranks it only as a variety of *Leptocolea floccosa* St. Zwickel (1938) treats the two as distinct species of his new genus *Tæniolejeunea*.

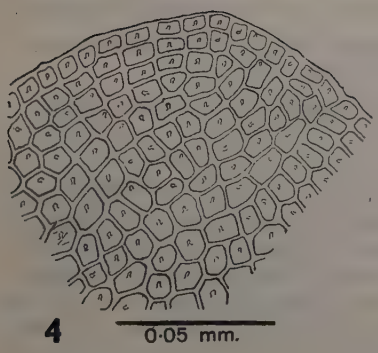
Diœcious, pale green, small, upto 5 mm. long, irregularly branched. *Leaves* imbricate, suberect, spreading, ovate-oblong, more or less falcate, about 0·8 mm. long and 0·5 mm. broad in the middle, inserted by a narrow base, entire, obtuse, papillate anteriorly. *Upper cells* $6\mu \times 6\mu$; *median* $6\mu \times 8$–9μ, *basal* $9\mu \times 15$–18μ; *ocelli* seriate, 4; 15–$18\mu \times 30$–36μ. *Lobule* large, ovate, one-third the size of the lobe, bidentate, teeth unequal, lower one larger. *Keel* curved, oblique, emarginate. *Andrœcia* spikate, terminal on the main or lateral shoots; *male bracts* 3 or 4, smaller than the foliage leaves, overlapping. Rest not seen. According to Stephani (1912–17) the *perianth* is small,

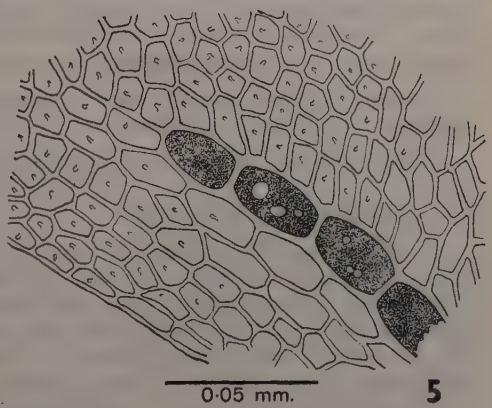












FIGS. 1-6

FIGS. 1-6. *Tæniolejeunea peraffinis* (Schffn.) Zwickel. Fig. 1. Part of plant dorsal view. Fig. 2. Part of plant, ventral view. Fig. 3. Lobule. Fig. 4. Cells from the apex of leaf. Fig. 5. Cells from the base of leaf showing ocelli. Fig. 6. A part of male shoct, ventral view.

compressed and inflated, broadly obcuneate, apex broadly truncate rotundate, beak small. Floral leaves as long as the perianth, obovate-oblong, apex rotundate, entire; anteriorly papillate. *Lobule* half the size of the leaf, oblong, twice or thrice as long as broad, apex obtuse, very much or slightly free.

Distribution in India—Gersoppa Falls, 4,000 ft. (Western Ghats, South India). Collector—S. K. Pandé, 1940; S. K. Pandé and K. P. Srivastava, 1950.

Agumbe, 2,500 ft. (Western Ghats, South India). Collector—S. K. Pandé and K. P. Srivastava, 1950.

Rimbic, 6,000 ft. (Darjeeling, Eastern Himalayas). Collector—S. K. Pandé, 1941.

2. *Tæniolejeunea pseudofloccosa* (Horikawa) Hattori.

Leptocolea pseudofloccosa was established by Horikawa (1932) on the basis of sterile specimen, growing on the leaves of *Plagiogyria formosana* from Formosa (Japan). Later, Hattori (1941) referred it to *Tæniolejeunea pseudofloccosa*. The specimen of this liverwort from Rimbic is fertile, bearing antheridia and perianth in various stages of development. The authors have therefore made an attempt to give a more or less complete account of this liverwort.

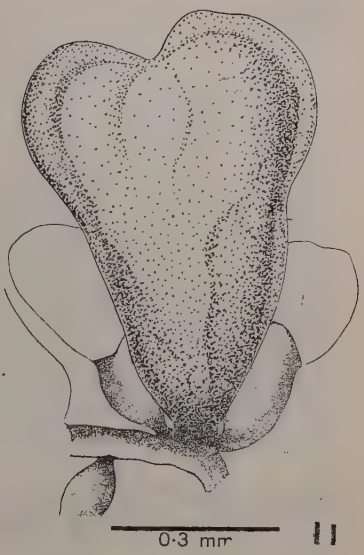
Monœcious, medium, yellowish green, growing firmly attached to substratum. *Leaves* imbricate, obliquely ascending, ligulate, oblong, about 0·45 mm.×0·3 mm., asymmetrical, obtuse, inserted by a narrow base, minutely serrate; *cells* pellucid, *upper cells* about 8 μ in diameter, *median* 10–12 μ×14–17 μ, *basal* 12–14 μ×24–30 μ, leaf cells finely tuberculate; trigones inconspicuous; walls stout. *Lobule* large, ovate, inflated or saccate, bidentate, both the proximal and distal teeth bicellular and crossing each other, apex obliquely truncate, margin coarsely toothed; *stylus* elongated, two-celled. *Andrœcia* terminal or lateral, *male bracts* 3 to 4 pairs; monandrous, antheridia spherical, short-stalked. *Perianth* terminal on main or lateral shoots, obcordate.

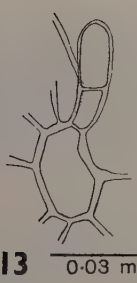
Distribution in India and Ceylon—Rimbic, 6,000 ft. (Darjeeling, Eastern Himalayas). Collector—S. K. Pandé, 1941.

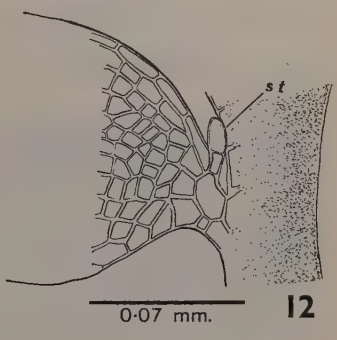
Pedros Peak, 8,300 ft. (Ceylon). Collector—S. K. Pandé, 1939.

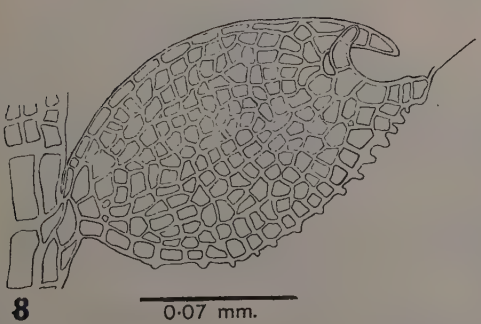
3. *Leptolejeunea schiffneri* St.

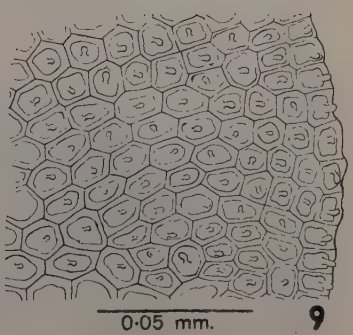
Leptolejeunea schiffneri, according to previous record, has been known from the island of Java. It was first described by Stephani (1896) and the description later reproduced by him (Stephani, 1912–17). In India the plant was first collected by Pandé in 1940 from the Gersoppa Falls, where it was found growing on the upper surface of living leaves of certain young palms and some dicots. Subsequently it was collected by Pandé and Srivastava in 1950 from the same locality, as well as from



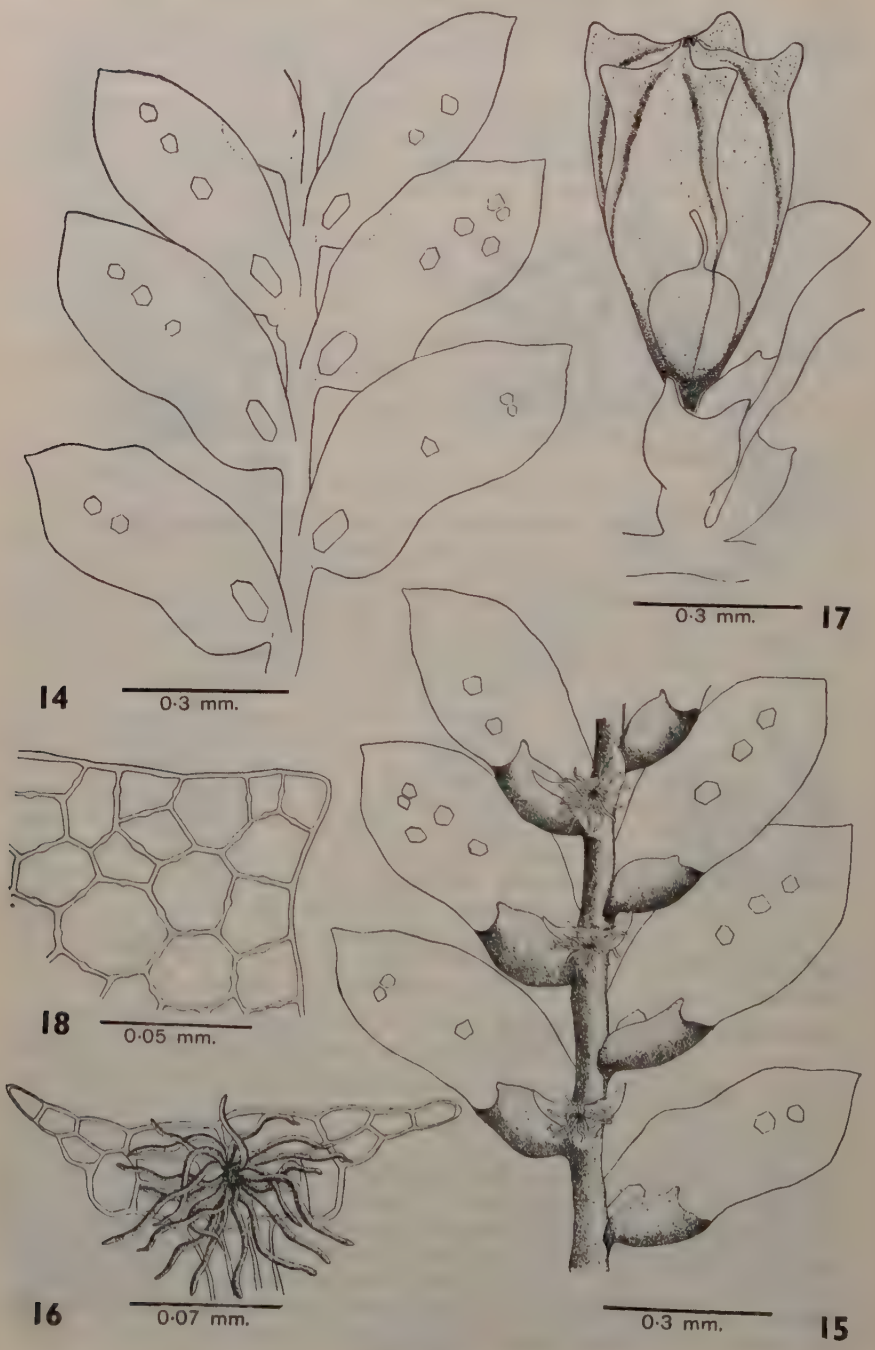








FIGS. 7–13



FIGS. 14–18

FIGS. 7–13. *Tæniolejeunea pseudofloccosa* (Horikawa) Hattori. Fig. 7. Part of plant with male shoot. Fig. 8. Lobule. Fig. 9. Leaf cells. Fig. 10. Male bract enclosing an antheridium (♂). Fig. 11. Perianth. Fig. 12. A portion of leaf showing stylus (*st*). Fig. 13. Stylus highly magnified.

FIGS. 14–18. *Leptolejeunea schiffneri* St. Fig. 14. Part of plant, dorsal view. Fig. 15. Part of plant, ventral view. Fig. 16. Amphigastrium. Fig. 17. Perianth. Fig. 18. Cells from apical portion of leaf.

Agumbe. The specimens are fertile and bear perianth in various stages of development. The observations recorded here are more or less in agreement with those of Stephani.

Dicœcious, small, dark brown, epiphyllous, shoots upto 2 cm. long, irregularly bipinnate. *Leaves* obliquely spreading, oblong, 1 mm. long, 0.5 mm. broad, subsymmetrical, broadly accuminate to acute. *Upper cells* 18 $\mu \times 21\ \mu$, *basal* 24 $\mu \times 45\ \mu$, *ocelli* seriate. *Lobule* oblong, obliquely ascending, about two times longer than broad. *Amphigastria* on the stem, large, basal disc entire, rectangular, apex broadly truncate. *Perianth* small, obovate-oblong, apex truncate; bracts shorter than the perianth. Rest not seen.

Distribution in India—Gersoppa Falls, 4,000 ft. (Western Ghats, South India). Collector—S. K. Pandé, 1940; S. K. Pandé and K. P. Srivastava, 1950.

Agumbe, 2,500 ft. (Western Ghats, South India). Collector—S. K. Pandé and K. P. Srivastava, 1950.

Rimbic, 6,000 ft. (Eastern Himalayas). Collector—S. K. Pandé, 1941.

4. *Drepanolejeunea foliicola* Horikawa

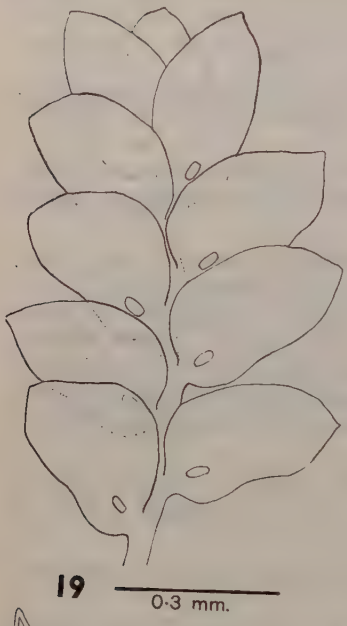
Drepanolejeunea (Spruce) Schffn. according to the census of Stephani (1912–17), embraces 85 species. Herzog (1930, 1934, 1936, 1939) has published a critical account of the genus describing several new species and some new varieties.

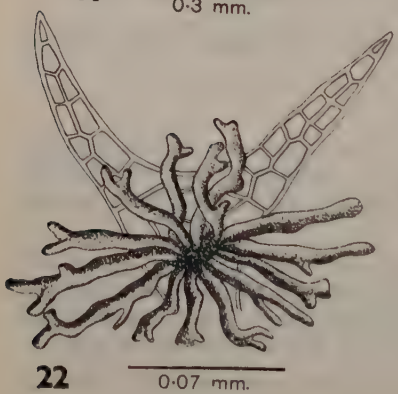
Drepanolejeunea foliicola was originally described by Horikawa from Japan. He found it growing on the leaves of *Plagiogyria formosana* and *Quercus stenophylla*. Specimens of this plant were collected by one of the authors (Pandé) from Rimbic in the Eastern Himalayas.

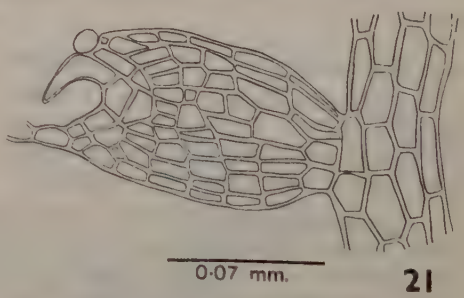
The specimen is sterile and more or less agrees with the description given by Horikawa (1932).

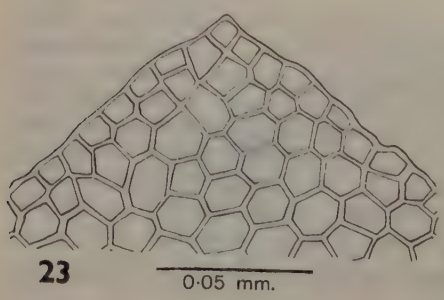
Sterile, epiphyllous, light green, pellucid, upto 1 cm. long. *Stem* 50–60 μ in diameter, branched. *Rhizoids* in fascicles. *Leaves* imbricate, expanded, subangled, broadly oblong, ovate, about 0·42 mm. long, 0·28 mm. broad; apex acute, rarely obtuse. *Upper cells* about 12 μ in diameter, *median* about 15 μ in diameter, *basal* about 15 $\mu \times 24\ \mu$. *Ocellus* single, above the base, 21 $\mu \times 45\ \mu$. *Lobule* about one-third the size of the lobe, 0·15 mm. long, 0·1 mm. broad, inflated. *Keel* curved, upper margin flat; tooth unicellular, acute, spiniform. *Amphigastria* on the stem, deeply bifid, sinus obtuse. Rest not seen.

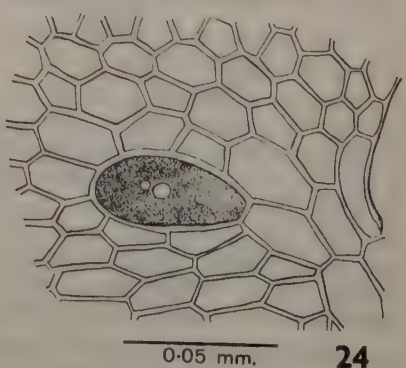
Distribution in India—Rimbic, 6,000 ft. (Eastern Himalayas). Collector—S. K. Pandé, 1941.











FIGS. 19–24. *Drepanolejeunea foliicola* Horikawa. Fig. 19. Part of plant, dorsal view. Fig. 20. Part of plant, ventral view. Fig. 21. Lobule. Fig. 22. Amphigastrium. Fig. 23. Leaf apex. Fig. 24. Base of leaf to show ocellus.

Table of Distribution of the Epiphyllous Liverworts in India and Ceylon

No.	Name	Distribution
1	*Leptocolea jelineckii* St., *Sp. Hep.* V, p. 851	Nicobars
2	*Leptocolea lanciloba* St., *Hedwigia*, 1895, p. 250, *Sp. Hep.*, V, p. 852	Nicobars, Gersoppa Falls (South India, Coll. Pandé; Pandé and Srivastava) Kulsi (Assam, Coll. Kachroo)
3	*Radula javanica* G., *Syn. Hep.*, p. 257. *Sp. Hep.*, IV, p. 186 = *R. kurzii* St. *Hedwigia*, 1884, p. 153	Kudremukh (South India, Coll. Pfleiderer)
4	*Radula protensa* Ldbg., *Sp. Hep.*, IV, p. 228. *Bot. Zeitg.*, 1848, p. 462	Gersoppa Falls (South India, Coll. Pandé).
5	*Taxilejeunea tenerrima* St., *Sp. Hep.*, VI, p. 406	Kudremukh (Coll. Pfleiderer)
6	*Rectolejeunea aloba* (Sande Lac.) St., *Sp. Hep.*, V, p. 696 = *Lejeunea aloba* Sande Lac. *Syn. Hep. Jav.*, 1856, p. 72	Gersoppa Falls (Coll. Pandé; Pandé and Srivastava)
7	*Leptolejeunea schiffneri* St., *Sp. Hep.*, V, p. 386. *Hedwigia*, 1896, p. 107	Gersoppa Falls (South India, Coll. Pandé; Pandé and Srivastava), Agumbe (South India, Coll. Pandé and Srivastava), Rimbic (Eastern Himalayas; Coll. Pandé)
8	*Leptolejeunea dapitana* St., *Sp. Hep.*, V, p. 379	Udipi (South India, Coll. Pfleiderer)
9	**Cololejeunea triangulilo ba* =*Physocolea triangulilo ba* St., *Sp. Hep.*, V, p. 907	Madura (South India)
10	**Cololejeunea hispidissima* =*Physocolea hispidissima* (St.) [Herz., *Ann. Bry.*, IV, 1931, p. 94 = *Leptocolea hispidissima* St. *Sp. Hep.*, VI, p. 423	Gersoppa Falls (South India), Coll. Pandé; Pandé and Srivastava), Kudremukh (South India, Coll. Pfleiderer)

TABLE—*Contd.*

No.	Name	Distribution
11	*Tæniolejeunea peraffinis* (Schffn.) Zwickel, *Ann. Bry.*, 1933, VI, p. 107 = *Physocolea peraffinis* Schffn. *Sp. Hep.*, V, p. 900 =*Cololejeunea peraffinis* Schffn., *Acad. Leopold.*, 1893, p. 242 = *Leptocolea floccosa* var. *peraffinis* (Schiffn.) Herz.	Gersoppa Falls (South India, Coll. Pandé; Pandé and Srivastava), Agumbe (South India, Coll. Pandé and Srivastava), Rimbic (Eastern Himalayas, Coll. Pandé)
12	*Lopholejeunea ceylanica* St., *Sp. Hep.*, V, p. 86	Ceylon
13	*Pycnolejeunea ceylanica* (G.) St. *Sp. Hep.*, V, p. 621 = *Lejeunea ceylanica* G. *Syn. Hep.*, p. 359 = *Lejeunea connivens* G. Schffn. *Gazella Exped.*, 1889	South India
14	*Frullania* Sp.	Pedros Peak (Ceylon, Coll. Pandé)
15	*Ceratolejeunea thwaitesiana* (Mitt.) St., *Sp. Hep.*, V, p. 445 = *Lejeunea thwaitesiana* Mitt. *Proc. Linn. Soc.*, 1861, p. 117	Ceylon
16	*Lejeunea* Sp. A	Ceylon (Coll. Pandé)
17	*Pycnolejeunea urticulata* St., *Sp. Hep.*, V, p. 625. *Hedwigia*, 1896, p. 126	Ceylon
18	*Drepanolejeunea thwaitesiana* (Mitt.) St., *Sp. Hep.*, V, p. 350 = *Lejeunea thwaitesiana* Mitt. *Proc. Linn. Soc.*, 1861, p. 117 = *Drepanolejeunea setistipa* St. *Hedwigia*, 1896, p. 83	Ceylon
19	*Drepanolejeunea* Sp.	Pedros Peak (Ceylon, Coll. Pandé)

TABLE—*Contd.*

No.	Name	Distribution
20	*Leptolejeunea maculata* (Mitt.) St. *Sp. Hep.*, V, p. 384 = *Lejeunea maculata* Mitt. *Proc. Linn. Soc.*, 1861, p. 118	Ceylon
21	*Leptolejeunea fleischeri* St., *Sp. Hep.*, V, p. 382	Ceylon
22	*Leptolejeunea epiphylla* (Mitt.) St., *Sp. Hep.*, V, p. 380 = *Lejeunea epiphylla* Mitt. *Proc. Linn. Soc.*, 1861, p. 118	Ceylon
23	*Microlejeunea* Sp. II	Pedros Peak (Ceylon, Coll. Pandé)
24	**Cololejeunea inflectidens* =*Physocolea inflectidens* (Mitt.) St., *Sp. Hep.*, V, p. 896 = = *Lejeunea inflectidens* Mitt. *Proc. Linn. Soc.*, 1861, p. 117	Ceylon
25	*Tæniolejeunea pseudofloccosa* (Horikawa) Hattori = *Leptocolea pseudofloccosa* Horikawa. *J. Sc. Hiroshima Univ.*, Ser. B, Div. 2, Vol. 1, p. 87	Rimbic (Eastern Himalayas, Coll. Pandé)
26	**Cololejeunea gottschei*= *Physocolea gottschei* St., *Sp. Hep.*, V, p. 894	Ceylon
27	*Leptolejeunea balansæ* St., *Sp. Hep.*, V, p. 377. *Hedwigia*, 1896, p. 105	Andamans
28	**Cololejeunea acinacifolia* =*Physocolea acinacifolia* St. *Sp. Hep.*, V, p. 887	Andamans
29	*Dicranolejeunea sikkimensis* St. *Sp. Hep.*, V, p. 170	Sikkim (Eastern Himalayas)

TABLE—*Contd.*

No.	Name	Distribution
30	*Drepanolejeunea foliicola* Horikawa, *J. Sci. Hiroshima Univ.*, Ser. B, Div. 2, Vol. 1, p. 85	Rimbic (Eastern Himalayas, Coll. Pandé)
31	*Leptolejeunea himalayensis* Pandé et Misra, *J. Indian bot. Soc.*, 1943, p. 168	Mungpoo (Eastern Himalayas, Coll. S. N. Das-Gupta)
32	*Lejeunea* Sp. B	Mungpoo (Eastern Himalayas, Coll. S. N. Das-Gupta)
33	*Microlejeunea* Sp. I	Darjeeling (Eastern Himalayas, Coll. Pandé)
34	**Cololejeunea diversifolia* =*Physocolea diversifolia* (Mitt.) St., *Sp. Hep.*, V, p. 892 =*Lejeunea diversifolia* Mitt. *Proc. Linn. Soc.*, 1861, p. 118	Eastern Himalayas
35	**Cololejeunea indica* Pandé et Misra, *J. Indian bot. Soc.*, 1943, p. 164	Mungpoo (Eastern Himalayas, Coll. S. N. Das-Gupta)
36	**Cololejeunea venusta* = *Physocolea venusta* (Sande Lac.) St., *Sp. Hep.*, V, p. 907 = *Lejeunea venusta* Sande Lac. *Syn. Hep. Jav.*, 1856, p. 64	Darjeeling (Eastern Himalayas) Kulsi (Assam, Coll. Kachroo)
37	*Aphanolejeunea* Sp. I	Jorpokhari (Eastern Himalayas, Coll. Pandé)
38	*Aphanolejeunea* Sp. II	Jorpokhari (Eastern Himalayas, Coll. Pandé)
39	*Leptolejeunea spathulifolia* St., *Sp. Hep.*, V, p. 386	Rimbic (Eastern Himalayas, Coll. Pandé).
40	*Radula assamica* St., *Sp. Hep.*, IV, p. 229. *Hedwigia*, 1884, p. 151	Assam

* As suggested by Evans (*Bryologist*, **41**: 71–82, 1938), the generic name *Cololejeunea* has been used for all the species of *Physocolea*.

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* Not seen in original.

MICROFOSSILS FROM A CARBONACEOUS SHALE NEAR VEMAVARAM (JURASSIC) IN THE EAST COAST GONDWANAS OF INDIA

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Introduction

During the recent years microfossil studies have attained considerable significance and much work has been produced in this line in Europe, America and Australia. From India the important contributions in this line are by Virkki (1946), Sahni, Sitholey and Puri (1948), Ghosh and Sen (1948), Ghosh and Bose (1950, 1952), Rao (1936, 1943), Rao and Vimal (1952, 1952 *a*), Sitholey, Srivastava and Verma (1953), Chitaley (1951), Vishnu Mittre (1954), and Sah (1955). Most of the above contributions deal with the materials from the Lower Gondwana and Tertiary rocks. Microfossils from the Jurassics of India have been studied by Rao (1943) and Vishnu Mittre (1954). Recently Sah (1955) has described microfossils from the Jurassic of Salt Range and also from a carbonaceous shale (Jurassic) in Andigama, Ceylon (Sah, 1953). From the East Coast Gondwana rocks of India the author is not aware of any (hitherto) published records of microfossil investigation.

Fossiliferous rocks of the Upper Gondwana age occur in numerous small patches and exposures along the Eastern Coast of India. Of these, the beds at Vemavaram are the most important in that they have yielded a larger number of comparatively better preserved fossils than any other fossiliferous bed in the East Coast of India. Vemavaram, close to which the fossiliferous rocks are exposed, is a small village 14 miles N.-E. of Ongole in the Guntur District. The fossiliferous shales are brownish, cream-coloured or purple to variegated and very hard. The Vemavaram group fossils are equivalent to the Kota series of the Indian Jurassic age. For a comprehensive study of the geology of the area reference may be made to the classical work of Bruce Foote (1879). It was Feistmantel (1879) who for the first time gave an illustrated description of the fossil plants from Vemavaram and its surrounding areas. Feistmantel's work, however, has been revised later on by Seward and Sahni (1920), and Sahni (1928, 1931). The fossils exposed here are mostly preserved in the form of impressions, incrustations or compressions; petrifactions, particularly woods, have also been reported but they are very few and far between and in general poorly preserved.

The material on which the present work is based, consists of a small piece of shale collected from near Vemavaram by the author in 1956 during a short visit to the fossiliferous localities near that place.

The Vemavaram shales, as a rule, are extremely hard and the fossils unfortunately show little or no carbonisation; numerous attempts to recover microflora from these shales proved to be of no great success. Among the author's collection there was a small carbonaceous shale which superficially looked to be quite unpromising. The shale was very hard, compact, darkish brown in colour with black carbonised streaks at many places. Along with the other shales, this shale was also macerated by the author. While in the case of the former the microfossil contents were very poor and almost negligible, the latter surprisingly enough yielded quite a good concentration of microspores, pollen grains, cuticles and wood pieces. The microspores and pollen grains are very abundant, cuticles are common but the tracheidal pieces are rare.

Technique

As a rule the Vemavaram shales do not undergo proper maceration in Schulze's solution (20 parts of 50–60% Nitric acid, and 3 parts of Potassium chlorate), consequently they were thoroughly ground up and then macerated in Hydrofluoric acid. But as regards the hard carbonaceous shale under consideration, two methods have been employed successfully for its maceration. In the first case, a small piece was broken from the shale and macerated for several days in Schulze's mixture, followed by treatment for a few hours with alkali (10% Ammonium hydroxide). The material after repeated washings was mounted in Canada-balsam. In the second case the shale was kept in 70% commercial Nitric acid for a number of days. When the shale had completely disintegrated it was thoroughly washed in distilled water and then kept in 10% aqueous ammonia for a few hours. The residue was then washed repeatedly till no trace of ammonia remained and subsequently transferred to a watch-glass, which on being gently shaken led to the separation of its constituents, *viz.*, microspores, cuticles and tracheids floating on the surface of the water while the heavier particles of sand, etc., remained at the bottom. The organic matter thus separated was stained in safranin and mounted in Glycerine Jelly and the cover glass sealed by Goldsize. The slides were prepared taking every possible care and precaution to eliminate any foreign contamination.

Classification of Fossil Spores

Classification of the fossil spores and pollen grains is a very difficult and delicate task, particularly so when we deal with *sporæ dispersæ*, about whose affinities utmost caution and restraint is to be exercised before saying anything definite. A critical study of the literature on the classification of fossil spores shows that different authors have based their individual systems according to convenience on entirely different characters. More often than not, different types of spores are described under the same name by different authors. For instance, Ibrahim (1933), Naumova (1937) and others put all spores bearing a trilete mark under the group *Triletes* while according to Dijkstra (1946) *Triletes* comprises only megaspores of Lycopodiaceous affinities.

Among the various systems of classification, mention may be made of those by Ibrahim (1933), and Potonie and Kremp (1954) in Germany, by Naumova (1937) and others in Russia, by Schopf, Wilson and Bentall (1944) in America, by Erdtman (1947) in Sweden and by Virkki (1946) and Pant (1954) in India.

The systems of classification proposed by Ibrahim (1933), Naumova (1937) and Erdtman (1947) were chiefly based upon the mode of germination and secondly on the sculpturing of the exine pattern. Ibrahim and Naumova's systems are quite simple and easy to follow. Besides their systematic value these schemes are useful for correlation purposes. But, in both of them the microspores and megaspores have not been treated as different categories. The nomenclature in Ibrahim's system of classification seems to be rather confusing and moreover pollen grains have not been considered at all in this scheme. Further the systems of both Ibrahim and Naumova are rather incomplete in the sense that they cannot accommodate all the numerous types of spores and pollen grains that one comes across in the fossil state.

Schopf, Wilson and Bentall's (1944) brilliant studies on the Palæozoic spore types resulted in the latter's classification into about 24 distinct, well-defined genera. Each genus is a separate entity by itself and unrelated to the other. The classification proposed by these authors was based *a priori* on many arbitrarily determined characters. This scheme is exclusively meant for Palæozoic spore types and hence may not be of much utilization when we deal with *sporæ dispersæ* from younger strata.

Erdtman's (1947) scheme of classification meant primarily for the pollen grains of living species, with its 13 ' cœnotypes ' seems to be more advanced and natural over the previous schemes. But here again the nomenclature is a bit confusing which may be evidenced by the fact that a minor change of alphabets ' *e* ' and ' *i* ' in the suffixes ' *lites* ' and ' *letes* ' distinguishes the micro from the megaspores. Moreover the various ' cœnotypes ' in Erdtman's system are treated as independent entities, unrelated to each other.

Virkki (1946) in India working on the Lower Gondwana spores attempted to classify them taking into account the presence or absence of wing as the chief character, without giving due importance to the mode of dehiscence which by itself constitutes a very fundamental and important diagnostic feature. Besides, the numerical nomenclature adopted by Virkki is not *in vogue* nowadays. Numerical nomenclature of the spores and pollen grains is of some use only in the correlation purposes but not in the systematic and orthodox morphological grouping of the microflora.

During the year 1954 Pant from India and Potonie and Kremp from Germany proposed two more systems of classification of spores and pollen grains occurring in the fossil state. Both these systems are distinctly superior to and comparatively more natural over the previous systems. In both the cases the basic arrangement of the groups, however, is somewhat on the lines of Ibrahim (1933) and Naumova's (1937)

schemes. While a comprehensive evaluation of both these recent schemes is not possible, it may be mentioned that the system, proposed by Potonie and Kremp (1954) takes into account mainly the spore types from the Palæozoic strata, while that of Pant (1954) seems to be more broader and includes the spores and pollen types from all the horizons. In this connection, the author feels that Pant should have supplemented his scheme of classification by illustrations which he has not done for some unknown reasons.

The spores and pollen grains in the present paper have been classified in accordance with Pant's (1954) system of classification. For some of the types which cannot be accommodated in any of the groups of this classification new groups have been proposed.

Description

SPORES

Phylum	**SPORITES**
Class	RIMALES
Sub-Class	*TRIRIMOSA*
Group	MICROSPORITES
Division	AZONALESPORITES
Sub-group	*Lævigatisporites*

Type 1

Pl. X, Fig. 1; Text-Fig. 1

Spore sub-triangular in polar view, 41 μ. Angles somewhat rounded, sides convex. Exine smooth or very finely granular. Trilete mark prominent, extending almost to the periphery of the body as seen in proximal view. Several specimens present.

Type 2

Pl. X, Fig. 2; Text-Fig. 2

Spore triangular in polar view, 30 μ. Angles markedly rounded, sides slightly retracted. Exine smooth. Tetrad scar extending more than three-fourths of the radial distance to the spore wall. Six specimens present.

Type 3

Pl. X, Fig. 3; Text-Fig. 3

Spore triangular in polar view, 22 μ. Angles rounded. Exine smooth with wrinkles. Trilete mark very wide, short, lips broadly open. Two specimens present.

Type 4

Text-Fig. 4

Spore sub-triangular, very small, 18 μ. Angles not exactly rounded. Exine lævigate, often folded. Trilete mark distinct, wide, arms short and rather thick. Two specimens present.

Type 5

Pl. X, Fig. 4

Spore tetrahedral, flat, very small, 15–19 μ. Angles acutely pointed. Exine considerably thick, smooth. Trilete mark clear, arms long reaching the periphery of the spore.

Type 6

Text-Fig. 5

Spore tetrahedral, sub-triangular, 44 μ. Angles strongly rounded, wall fairly thick, 2·5 μ. Trilete mark short, thick, usually not reaching the periphery of the body. Four specimens present.

Sub-group—*Punctatisporites*

Type 1

Pl. X, Fig. 5

Spore sub-triangular in polar view, 35 μ. Exine thick, with pronounced punctuations in the form of small blunt, rods which often project out from the margin. Trilete mark faint. Two specimens present.

Type 2

Pl. X, Fig. 6

Spore rounded to sub-triangular in polar view, 30 μ. Exine thick, ornamented with very fine punctuations which project out from the margin of the spore as short rods. Trilete mark distinct, but rather slender with arms reaching three-fourths of the radial distance to the spore wall. Two specimens present.

Sub-group—*Camptosporites*

Type 1

Pl. X, Fig. 7; Text-Fig. 6

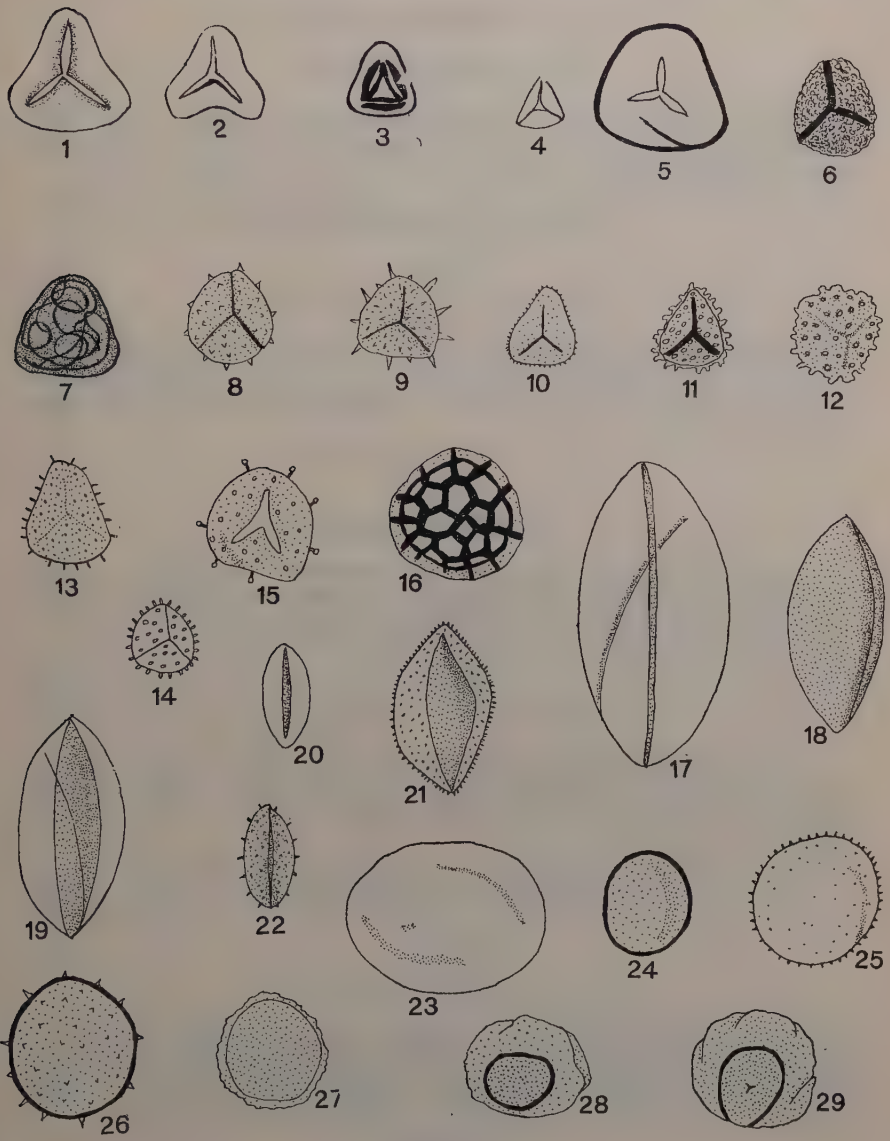
Spore rounded, about 29 μ. Exine flexuous, dissected and thrown into many shallow projections of minute size, dovetailing irregularly into one another. Trilete mark distinct, arms of the trilete thick and reach to the margin of the spore body. Six specimens present.

Sub-group—*Periplecosporites*

Type 1

Pl. X, Fig. 8

Spore rounded, 32 μ. Exine thin and bearing numerous interwoven circular ridges; often folded. Trilete mark not clear. Four specimens present.



TEXT-FIGS. 1–29

Figs. 1–27. Microspores. Figs. 1–5. *Lævigatisporites*. Fig. 6. *Camptosporites*. Fig. 7. *Periplecosporites*. Figs. 8–10. *Apiculatisporites*. Figs. 11, 12. *Tuberculatisporites*. Figs. 13, 14. *Setosisporites*. Fig. 15. *Piliferosporites*. Fig. 16. *Zonalereticulatisporites*. Figs. 17–20. *Lævigatimonoletes*. Figs. 21, 22. *Apiculatimonoletes*. Figs. 23, 24. *Lævigataletes*. Figs. 25, 26. *Apiculataletes*. Fig. 27. *Lævigatazonaletes*. Figs. 28, 29. One-winged pollen grains (*Florinites*?). All figures, ×450.

Type 2

Pl. X, Fig. 9; Text-Fig. 7

Spore triangular, 34 μ. Angles somewhat rounded. Exine thick with many fairly thick irregular interwoven ridges. Trilete mark faint. Two specimens present.

Sub-group—*Apiculatasporites*

Type 1

Pl. X, Fig. 10; Text-Fig. 8

Spore tetrahedral, sub-triangular in proximal view, 32 μ. Exine with prominent, sharply pointed spines, 4 μ long. Trilete mark distinct, arms thick, long, reaching the periphery of the spore. Three specimens present.

Type 2

Pl. X, Fig. 11; Text-Fig. 9

Spore tetrahedral, triangular in proximal view, 28 μ. Exine echinate, spines narrow, but elongated, 6 μ long. Trilete mark distinct, arms short and blunt. Two specimens present.

Type 3

Pl. X, Fig. 12; Text-Fig. 10

Spore sub-triangular in proximal view, 20 μ. Exine echinate, spines sharp, but extremely small, numerous and closely oriented. Trilete mark fairly distinct, arms narrow, long. Two specimens present.

Sub-group—*Tuberculatisporites*

Type 1

Pl. X, Fig. 13; Text-Fig. 11

Spore triangular or sub-triangular in polar view, 28 μ. Exine thick with prominent tubercles all over it. Tubercles short, very blunt and flat at the top. Trilete mark distinct, arms thick, long almost reaching the periphery of the spore. Three specimens present.

Type 2

Pl. X, Fig. 14; Text-Fig. 12

Spore rounded to sub-triangular in polar view, 32 μ. Exine of considerable thickness, studded all over with blunt, very short tuberculate processes with round heads. Triradiate scar not distinct. Four specimens present.

Sub-group—*Setosisporites*

Type 1

Text-Fig. 13

Spore rounded in polar view, about 26 μ. Exine with blunt spinescent projections, 2·5–4 μ long. Triradiate scar distinct, arms slender, but elongated. Two specimens present.

Type 2

Pl. X, Fig. 15; Text-Fig. 14

Spore rounded or slightly flattened, 20–30 μ. Exine with blunt spinescent processes, 2–3 μ long. Triradiate mark short and rather wide open, arms ending blindly. Six specimens present.

Sub-group—*Reticulatisporites*

Type 1

Pl. X, Fig. 16

Spore sub-triangular to often rounded in polar view, 35 μ. Exine with prominent reticulate ridges. Meshes open, polygonal, $8 \times 12\,\mu$. Muri thick and black and produced at the margin of the spore into short blunt rod-like processes which impart to the spore a somewhat echinate appearance. Trilete mark rather faint, arms slender but long. Several specimens present.

Type 2

Pl. X, Figs. 17, 18

Spore sub-triangular, about 27 μ. Exospore bearing thick reticulate ridges. Meshes polygonal, $7 \times 10\,\mu$. Trilete mark fairly distinct, arms slender, short and somewhat pointed. Six specimens present.

Type 3

Pl. X, Fig. 19

Spore rounded, 32 μ. Exospore with thick reticulate ridges. Meshes broadly open, hexagonal and slightly bigger than in the above spore, $8 \times 11\,\mu$. Trilete mark not clear. Three specimens present.

Type 4

Pl. X, Fig. 20

Spore sub-triangular to oval, $30 \times 26\,\mu$. Exospore with very thin reticulate ridges. Meshes irregular and of various shapes, $7 \times 9\,\mu$. Trilete mark present, but very faintly seen. Trilete short, slender and ending blindly. The photo given could not bring out the nature of the trilete mark. Three specimens present.

Type 5

Pl. X, Fig. 21

Spore sub-triangular to triangular, 38 μ. Exospore thick and studded with very thick, dark ridges of reticulate nature. Meshes usually hexagonal, considerably wide, $8 \times 12\,\mu$. Muri of the reticulum drawn out at the periphery of the spore into fairly long and blunt spine-like processes. Trilete mark very distinct, arms very thick and long reaching almost to the periphery of the spore.

Piliferosporites—a new sub-group

Trilete spore with the exospore bearing distinct pila or club-shaped processes.

Type 1

Pl. X, Figs. 22, 23; Text-Fig. 15

Spore rounded often sub-triangular, 26–36 μ. Exine of considerable thickness, studded with distinct club-shaped process, 3–6 μ long. Each pila possesses a fairly thick, short basal stalk with rounded swollen top-end. The pila are widely scattered on the exospore. Trilete mark distinct but very short, arms very thick and blunt, ending blindly. Four specimens present.

Striatotuberculatisporites—a new sub-group

Trilete spores with the exospore characterized by the possession of symmetrically oriented striations which bear on them short, thick and plumpy tuberculate processes. This type of exine pattern is different from the interwoven ridges of *Periplecosporites* (Pant, 1954) and from the parallel, asymmetrical, dichotomizing striations of *Litratosporites* (Vishnu Mittre, 1954).

Type 1

Pl. X, Figs. 24, 25

Spore triangular in polar view, 38 μ. Angles rounded. Exine thick with neat striations systematically oriented round the trilete mark. Striations bear many short, thick, bulging tuberculate processes. Trilete mark slender but with long arms almost reaching the periphery of the spore. Fig. 24 is the polar view, while Fig. 25 is the lateral view of the same type of spore. The striations and the tubercles appear very distinctly when the spore is examined in its lateral aspect.

Sub-group—*Litratosporites*

This was created by Vishnu Mittre (1954) for tetrahedral spores in which the exine shows asymmetrical, dichotomizing striations.

Type 1

Pl. X, Fig. 26

Spore triangular or sub-triangular in polar view, rather big, 48 μ. Angles more or less arched. Exospore thick, striated; striations thick,

bar-like, asymmetrical and often branched. Triradiate scar very faintly seen, short and slender. Three specimens present.

Division—ZONALESPORITES

Reticulatazonalesporites—a new sub-group

Type 1

Text-Fig. 16

Spore rounded, 35 μ, and surrounded all over uniformly by a colourless, delicate, flange-like frill or outer margin. Exine very thick and bears equally thick reticulate ridges which at the periphery of the spore drawn out into thick, short to long blunt or pointed processes penetrating the outer zone. Meshes big, 10–14 μ, hexagonal to polygonal. Trilete mark fairly distinct, arms long, slender, almost reaching the periphery of the spore body. Five specimens present.

Sub-class—*MONORIMOSA*

Group—MONOLETES

Pant (1954, p. 53) classified the group *Monoletes* into two sub-groups, *viz.*, *Azonomonoletes* and *Zonomonoletes*. *Azonomonoletes* type of spores, fossil as well as living, exhibit so many diverse types of exine patterns (Knox, 1938; Selling, 1946) that *Azonomonoletes* as a sub-group may not be found to be suitable to include all such types. Hence Vishnu Mittre (1954) has raised this sub-group along with *Zonomonoletes* to the status of divisions and then created new sub-groups to include all different types of spores with diverse exine patterns. The author agrees with Vishnu Mittre in raising the status of Pant's (1954) sub-groups to divisions.

Division—AZONOMONOLETES

Sub-group—*Lævigatimonoletes*

This was created by Vishnu Mittre (1954) for monoletes, bilateral spores with lævigate exine.

Type 1

Pl. X, Fig. 27; Text-Fig. 17

Spore bilateral, 60×38 μ. Boat-shaped, upper and lower ends become gradually pointed. Furrow single, median, longitudinal, uniformly narrow and extends from one end of the body to the other. Exine thin, smooth or finely granular and often folded. Several specimens present.

Type 2

Pl. X, Fig. 28; Text-Figs. 18, 19

Spore bilateral, ellipsoidal, 45×30 μ. Upper and lower ends pointed. Furrow single, median, longitudinal, broad at the middle and pointed at the ends, and extends from one end of the body to the other.

Exine thin, smooth, often wrinkled. About a dozen specimens present.

Type 3

Text-Fig. 20

Spore bilateral, ellipsoidal, $25 \times 18\,\mu$. Furrow median, longitudinal, narrow and short. Five specimens present.

Apiculatimonoletes—a new sub-group

Monolete spores with the exine echinate.

Type 1

Text-Fig. 21

Spore monoletes, bilateral, boat-shaped, $35 \times 25\,\mu$. Exine rather thick, and studded with numerous, very closely oriented, extremely fine and short spinescent processes. Furrow median, longitudinal, fusiform, rather broad and extends from one end of the body to the other. Four specimens present.

Type 2

Text-Fig. 22

Spore bilateral, ellipsoidal, $25 \times 21\,\mu$. Exine with many widely spaced, fine and short spines. Furrow median, longitudinal, narrow and rather short. Three specimens present.

Class—IRRIMALES

Pant (1954, p. 53) classified the *Irrimales* into two sub-groups, *viz.*, *Azonaletes* and *Zonaletes*. But at the same time he mentioned that these might be regarded as divisions and further subdivided into sub-groups like those of *Azonotriletes* and *Zonales*. The author thinks that this is the right procedure since spores without any slit or dehiscence mark show so many different kinds of exine patterns that to include all such types under *Azonaletes* would be quite misleading and inappropriate. It is with this view *Azonaletes* and *Zonaletes* have been here raised to the rank of divisions under class *Irrimales* and new subgroups created to accommodate spores showing different exine sculpturing.

Division—AZONALETES

Sub-group—*Lævigataletes*

Alete spores with smooth walls. This was created by Vishnu Mittre (1954).

Type 1

Text-Fig. 23

Spore ovoid, $45 \times 30\,\mu$. Exine thin, smooth often showing wrinkles. Several specimens present.

Type 2

Text-Fig. 24

Spore spherical, 15–20 μ. Exine very thick, but smooth and often traversed by irregular folds. Several specimens present.

Apiculataletes—a new sub-group

Type 1

Text-Fig. 25

Spores spherical, 20–28 μ. Exine thin, with numerous very closely spaced, extremely small and pointed spines. Spore wall generally shows longitudinal folds. Five specimens present.

Type 2

Text-Fig. 26

Spore spheroidal, 23–26 μ. Exine thick, with relatively long, finely pointed and widely spaced spines. Five specimens present.

Division—ZONALETES

Lævigatazonaletes—a new sub-group

Alete spores with sharply defined flexuous margin, exine smooth.

Type 1

TEXT-Fig. 27

Spore spheroidal, 22 μ. Body surrounded on all sides by a distinct, membraneous flexuous, colourless margin. Exine smooth, or finely granular. Six specimens present.

POLLEN GRAINS

Phylum .. **POLLENITES**
Class .. APOROSA
Group .. SACCATA
Sub-group *Florinites* ?—*One-winged pollen*

Type 1

Pl. X, Figs. 29, 30; Text-Figs. 28, 29

Grain more or less spherical, sometimes flattened on the promixal side. Body 33 μ. Overall size of the grain including the wing, 40–47 μ. Body surrounded by a single, fairly large, frilled and membranous cap-like wing or bladder (sac) covering all but a small portion. Exine granular to smooth. Dehiscence mark represented by a small, vestigial triradial scar. Generally the pollen grain of this type does not show any dehiscence mark, and the single bladder is often variously folded. About ten specimens present.

This grain is comparable to a considerable extent to the genus *Florinites* created by Schopf, Wilson and Bentall (1944) for a Palæozoic pollen.

Sub-group—*Alisporites*

Pollen grains with two flattened wings placed symmetrically on the two lateral sides of the body. There are various types in this sub-group. The pollen of this type shows considerable variation in size, shape and nature of the exine pattern, and wings. In most of the cases the bladders are larger than or at least equal to the size of the body proper.

Type 1

Pl. XI, Fig. 31

Pollen grain two-winged and considerably small in size. Body very small being only $18 \times 16\,\mu$, wings slightly larger than the body, $20 \times 21\,\mu$. Body proper elliptical or ovoid, very finely granular, margin rather thin. Wings symmetrically oriented on the sides of the body, very finely reticulate, with extremely small meshes of irregular shapes and sizes; often almost granular. Dehiscence mark represented by a single median, longitudinal furrow. Furrow open and rather wide when compared to the size of the body. Three specimens present.

Type 2

Pl. XI, Fig. 32; Text-Fig. 30

Body elliptical, elongated in vertical direction, almost of the same colour as the wings. Wings two, placed symmetrically, nicely preserved, bigger than the body; they show fine reticulations with hexagonal to polygonal meshes. Body coarsely granular with a more or less thick rim or cap. Dehiscence mark seen as median, longitudinal, fusiform furrow on the body. Body $30 \times 18\,\mu$. Wings $34 \times 20\,\mu$. Several specimens present.

Type 3

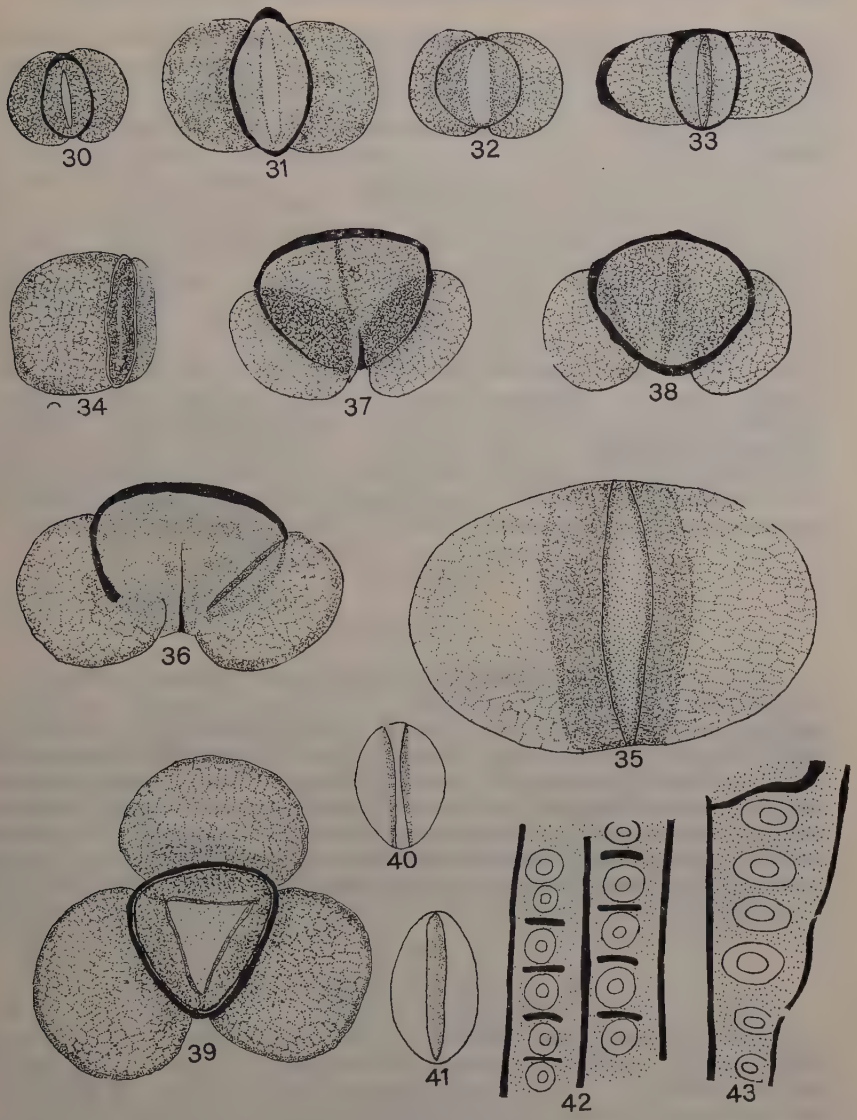
Pl. XI, Fig. 33; Text-Fig. 31

Pollen grain two-winged, body broadly elliptical, $34 \times 26\,\mu$. Margin thick, cap also of considerable thickness. Wings lateral, distinctly separate, slightly bigger than the body, $38 \times 28\,\mu$; they show coarse or rugged reticulations. Meshes polygonal, fairly large. Body wall finely reticulated. Dehiscence mark seen faintly as longitudinal, fusiform furrow. About fifteen specimens present.

Type 4

Pl. XI, Fig. 34; Text-Fig. 32

Body spheroidal to oval, $35\,\mu$. Margin thickened, cap also equally thick. Wings two, laterally oriented, separate, almost of the same size as that of the body or slightly bigger. Wings finely reticulate, meshes polygonal, small. Body wall coarsely granular. Dehiscence mark not distinct. Several specimens present.



TEXT-FIGS. 30–43

Figs. 30–41. Pollen grains. Figs. 30–35. *Alisporites*. Figs. 36–38. *Pityosporites*. Fig. 39. *Podosporites*. Figs. 40, 41. *Entylissa*. Fig. 39, ×550. The rest, ×450. Figs. 42, 43. Tracheidal pieces with bordered pits, ×450.

Type 5

Pl. XI, Fig. 35; Text-Fig. 33

Pollen two-winged, body oval to oblong, $27 \times 18\,\mu$. Margin thin, cap thickened. Wings symmetrically oriented on the sides, flattened,

and transversely stretched. Slightly bigger than the body, coarsely reticulate, meshes irregular, generally with the longer axis transverse to the body. Body wall finely reticulate. Dehiscence mark seen as wide, deep furrow with somewhat pointed ends. Many specimens present.

Type 6

Pl. XI, Fig. 36; Text-Fig. 34

Pollen two-winged. Body elliptical and greatly stretched vertically, $36 \times 16\,\mu$. Exine very thick, very coarsely granular. Wings laterally placed; of the two wings only one shows full growth, while the other is abortive. Wing when fully developed is much bigger than the body, coarsely reticulate; strands of the reticulations rather thick, meshes irregular in shape and size. Dehiscence mark represented by a single, median, longitudinal narrow furrow. In almost all the cases the furrow seems to be more or less closed. The abortive nature of one of the wings appears to be a normal feature as almost all the numerous specimens examined show this nature. Several specimens present.

Type 7

Pl. XI, Fig. 37

This is particularly large, two-winged pollen of infrequent occurrence. Body broadly or narrowly elliptical, 25 to $42\,\mu$ across, but its outline is faint and difficult to see. Overall length of the grain, 90–$115\,\mu$, width, 60–$75\,\mu$. Wings large, generally more or less fused thoroughly and then encircling the grain as single bladder; they, however, extend along the whole length of the grain. Sculpturing of the wings consists of finely reticulate ridges, with small, irregular meshes, of the body coarsely granular. Dehiscence mark represented by a large, but faintly seen, fusiform furrow. Three specimens present.

Type 8

Pl. XI, Fig. 38; Text-Fig. 35

Pollen of giant size, measuring $65–75 \times 100–120\,\mu$, including the wings. Body roughly spherical or broadly elliptical and rather flattened, 40–$55\,\mu$. Its outline indistinct. Wings almost of the same size as that of the body or slightly bigger, generally fused laterally and encircling the body as a single bladder. Wings possess large-meshed nicely preserved reticulum, which progressively becomes small-meshed as we reach from the margin of the wing towards the rim of the body. Body wall shows very fine, extremely small-meshed reticulum. Three specimens present.

Sub-group—*Pityosporites*

Pollen with two lateral bulbous wings or bladders tilted toward the ventral (distal) side of the body.

Type 1

Pl. XI, Fig. 39; Text-Fig. 36

Pollen two-winged, body spheroidal, about 36 μ. Wings bulbous or sac-like, placed distally, smaller than the body, $30 \times 26\,\mu$. Rim of the body fairly thick, wall coarsely granular, becoming very much so at the cap portion. Wings possess delicate ridges in a reticulate manner; meshes hexagonal or polygonal and of various sizes. Dehiscence mark seen as a short, narrow, longitudinal furrow. Several specimens present.

Type 2

Pl. XI, Fig. 40; Text-Figs. 37, 38

Pollen two-winged. Body oval or sub-triangular, 30–41 μ. Wings sac-like, slightly smaller than the body. Rim of the body very thick and flange-like, exine finely reticulate. Wings coarsely reticulate, meshes irregular and of various sizes. Dehiscence mark seen as a faint fusiform furrow. Six specimens present.

Sub-group—*Podosporites*

Pollen with three wings.

Type 1

Pl. XI, Fig. 41; Text-Fig. 39

Pollen three-winged, of medium size. Body rounded or sub-triangular in polar view; $39 \times 31\,\mu$ including the wings. Wings nicely preserved, bulbous, either with a space between them or meeting laterally; usually inserted along the sides of the body symmetrically. Reticulum of the wings well defined, meshes fairly large and of various shapes. Exine of the body very thick and two-layered; sculpturing finely rugulate, becoming coarsely so at the periphery of the body. Dehiscence mark seen as a more or less triangular-shaped, wide open furrow. Three specimens present.

Group –Intorta

Sub-group—*Entylissa*

Type 1

Pl. XI, Fig. 42; Text-Fig. 40

Pollen monocolpate, rather broadly ellipsoidal or boat-shaped, $29 \times 18\,\mu$. Exine smooth bearing a single longitudinal furrow reaching both the ends of the body. Ends of the furrow arched or rounded. Several specimens present.

Type 2

Pl. XI, Fig. 43

Pollen monocolpate, ellipsoidal, slightly narrower than the above one, $28 \times 14\,\mu$. Exine smooth bearing a single longitudinal furrow,

broad at the centre and pointed at the ends, and reaching from one end of the body to the other. Several specimens present.

Type 3

Text-Fig. 41

Pollen monocolpate, boat-shaped, twice longer than body, $45 \times 23\,\mu$, with two involute lobes enclosing a wide, deep longitudinal furrow with narrowed ends. Exine smooth. This grain differs from the above one in its greater size.

WOOD FRAGMENTS

As mentioned in the earlier part of this paper, wood fragments in general are few and far between in the macerated material; they are poorly preserved and hence not suitable for detailed study.

Type 1

Text-Fig. 42

The radial facets of the tracheids are preserved. Tracheids thick-walled. Radial pits bordered, large, $8–12\,\mu$, circular to slightly oval, separate and uniseriate. In between the adjacent pits fairly thick transverse bars are present which probably represent the bars of Sanio.

As the material is very poor we cannot say much about the affinities of these tracheids. But the presence of uniseriate, circular and separate bordered pits along with the bars of Sanio suggests relationship with Abietineæ.

Type 2

Text-Fig. 43

Tracheids thick-walled. Radial pits bordered, large, $10–16\,\mu$, flattened, uniseriate and separate.

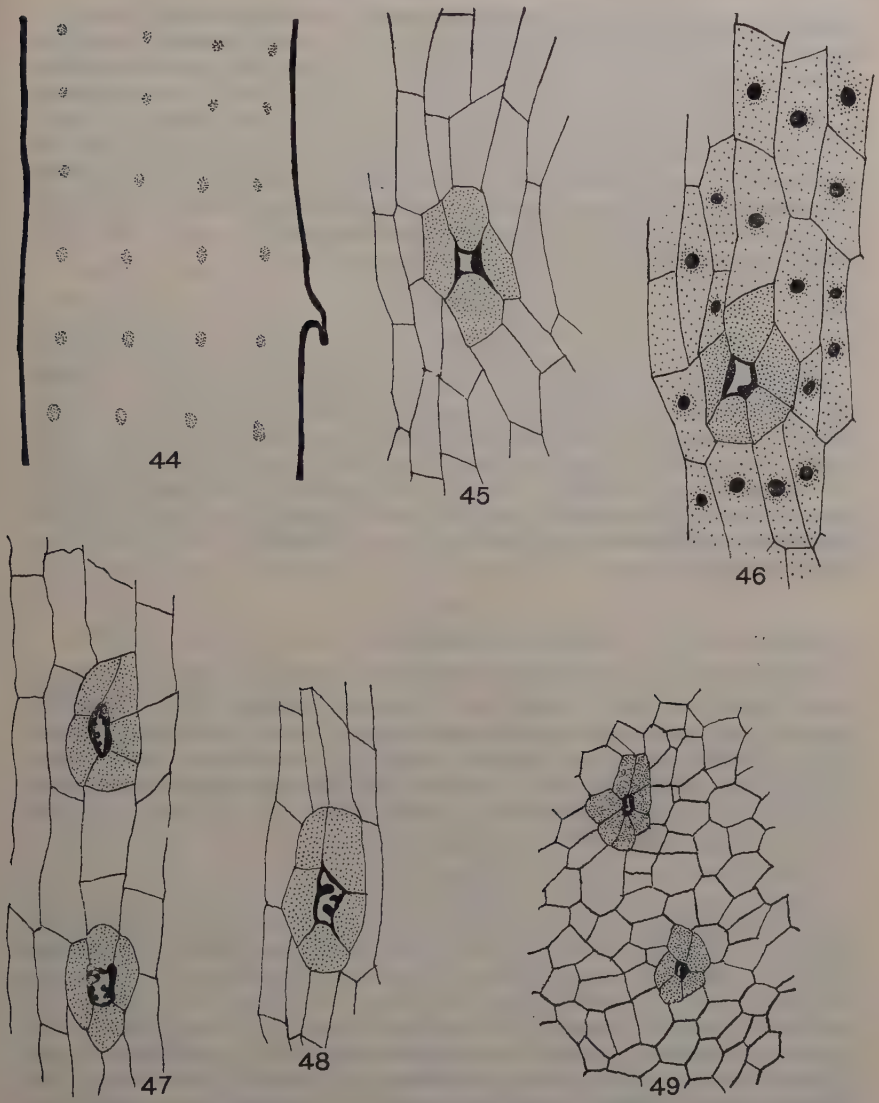
CUTICLES

The macerated sediment contains many finely preserved cuticular pieces, most of which are rather small. They all appear to be coniferous.

Type 1

Text-Figs. 44, 45

Cuticles with smooth epidermal cells, aligned in longitudinal rows and varying in shape from rectangular to squarish or polygonal; walls straight and fairly thick, end walls oblique. Stomata large, longitudinally oriented, and arranged uniformly in regular longitudinal seriations and separated from one another by the width of 2–3 stomata. Guard cells, sunken or depressed, surrounded by a complete ring of 4–5 subsidiary cells. Epidermal cells $41 \times 32\,\mu$. Subsidiary cells $36 \times 29\,\mu$. Several pieces present.



TEXT-FIGS. 44–49. Cuticular fragments, showing the stomata and the nature of the epidermal cells. Fig. 44, ×25. The rest, ×350.

Type 2

Text-Fig. 46

Cuticle with mostly rectangular cells; walls smooth, straight and fairly thick, end walls generally oblique. Stomata longitudinally oriented in regular rows. Guard cells thick, sunken, surrounded on

all sides by a ring of five subsidiary cells. In almost every cell there can be seen one or more well-defined thick, circular bodies, the exact nature of which is not known for certain. It is possible that these constitute the bases of deciduous hairs like those described by Nathorst (1907) in *Dictyozanites Johnstrupi*, by Thomson and Brancroft (1913) in *Tæniopteris vittata* and by Rao (1943 *a*) in *Tæniopteris spatulata*. Such circular bodies are seen in all the cuticular pieces showing the aforementioned characters, a fact which probably indicates that these are normal features of these cuticles. Epidermal cells $45 \times 31\,\mu$. Subsidiary cells $32 \times 25\,\mu$. Six pieces present.

Type 3

Text-Figs. 47–48

Cuticle with rectangular, vertically elongated, smooth, straight and thick-walled epidermal cells arranged in longitudinal rows; end walls transverse or slightly inclined. Stomata aligned in distinct longitudinal seriations. Guard cells thick, deeply sunken and encircled by a ring of 4–7 subsidiary cells. Inner walls of the subsidiary cells project over the guard cells into the stomatal opening as thick, papillate outgrowths. Epidermal cells $50 \times 28\,\mu$. Subsidiary cells $38 \times 32\,\mu$. Several pieces present.

Type 4

Text-Fig. 49

Cuticle with oroad, short, polygonal, smooth, straight and thick-walled epidermal cells; end walls oblique. Stomata few, lie widely scattered and show no definite orientation. Guard cells thick, deeply sunken, surrounded by a complete ring of 6–8 subsidiary cells. Inner walls of the subsidiary cells often project into the stomatal chamber as plumpy, papilla-like processes. Epidermal cells $35 \times 50\,\mu$. Subsidiary cells $35 \times 29\,\mu$. Five specimens present.

Discussion

The microflora recovered from a carbonaceous shale collected near Vemavaram in the East Coast of India comprises a large assemblage of spores, pollen grains, cuticles and wood fragments. Of these the microspores and pollen grains constitute the major part, while the cuticles and wood fragments are next in order of their abundance. The spores and pollen grains when classified according to Pant's system of classification appropriate themselves into about 25 distinct sub-groups; each sub-group consisting again of many different types. The majority of the microspores seem to be pteridophytic and include both the trilete and the monolete (bilateral) types. The pollen grains, cuticles and wood fragments are gymnospermic.

Affinities

Pteridophytic spores.—Some of the spores described under the sub-group *Lævigatisporites* are easily comparable in their size, shape and nature of the exine pattern to the spores of the modern Gleicheniaceæ (Selling, 1946).

Apiculatisporites Type 1 recalls in its structural details the microspores of some of the present-day species of *Selaginella* (Knox, 1938, 1950); while spores described under the sub-group *Reticulatisporites* are closely similar to those of *Lycopodium* species (Knox, 1938, 1950; Erdtman, 1943; Selling, 1946). In the nature of the exine sculpturing, in the size and orientation of the trilete mark and last but not the least in their size and shape, the types of spores described under *Reticulatisporites* seem to be remarkably similar to and almost indistinguishable from the spores of the modern species of *Lycopodium*.

Spores described under the new sub-group *Striatotuberculatisporites* seem to be very peculiar and highly interesting. In possessing symmetrically arranged striations around the trilete scar they strongly resemble some of the spore types of Schiziaceæ (Selling, 1944; Cookson, 1953). And it may be mentioned, that some of the Cyatheaceæ (Knox, 1838) spore types also possess fine striations, but here the striations are asymmetrical. The unique feature of the *Striatotuberculatisporites*, however, is the possession of distinct, plumpy, tubercles on and along the striations.

Spores described under *Litratosporites* in possessing asymmetrically aligned, parallel, branching striations seem to approach the Cyatheaceous spore types.

Monolete spores occur commonly in the shale. It is very difficult to speak of their affinities. Some of them may be of pteridophytic nature.

Pollen grains.—The pollen grains include both winged as well as unwinged types. The winged types are by far the abundant ones and show quite a gamut of variation in their size, shape, and ornamentation. The grains present in our collection are one to three-winged. One-winged grains are more or less comparable to Schopf, Wilson and Bentall's (1944) *Florinites*. The two-winged grains are comparable to Podocarpaceous and Abietineous pollen, in the latter case particularly, with the pollen of *Pinus*, *Picea* and *Cedrus*. *Alisporites* Types 7 and 8 in their giant size and the nature of their bladders resemble to some extent the pollen of the modern species of *Abies* (Wodehouse, 1935).

Three-winged grains are rather rare in our collection. Among the contemporary conifers, three-winged grains are produced by some of the Podocarpaceæ, *viz.*, *Podocarpus dacrydioides*, *Pherosphæra Fitzeraldi*, *P. Hookeriana* and *Microcachrys tetragona* (Wodehouse, 1935; Thomson, 1909; Erdtman, 1943). Besides in Abietieneæ three- and four-winged grains are occasionally produced in *Abies balsamifera*, *Pinus exelsa*, *Cedrus deodara* (Wodehouse, *loc. cit.*, pp. 258–61; Erdtman, *loc. cit.*, p. 130; Puri, 1945), and *Picea Smithiana* (Lakhanpal and Nair, 1956). Our specimens of three-winged grains in their size and other structural details approach those of Podocarpaceæ. Cookson and Pike (1953) recently described some three-winged grains from the Tertiary of Australia under the name *Dacrycarpites australiensis*, which seem to be greatly comparable to our specimens.

Pollen grains described under the sub-group *Entylissa* are monocolpate and comparable to the pollen of Bennettitales, Ginkgoales and Cycadales (Wodehouse, 1935). In the case of *Ginkgo* the grains are longer than broad, in Cycadales they are almost as broad as long. The pollen grains of Bennettitales are similar to those of *Ginkgo* but they are much larger in size (Wodehouse, *loc. cit.*, p. 233). If then, size is the criterion for the identification of the pollen of the above groups, *Entylissa* Type 1 seems to be more Ginkgoalean and *Entylissa* Type 2, more Bennettitalean.

Comparison with the microspores from the Rajmahal series

As has been mentioned in the earlier part of this paper, the Vemavaram plant fossils belong to the Jurassic age of the Upper Gondwanas of India. In the Jurassic of India are included three principal series of strata named Rajmahal, Kota and Jabbalpur. The Rajmahal is believed to be the oldest and the Jabbalpur the youngest of the three series. However, there is still considerable doubt regarding the relative ages of the Kota and the Rajmahal series, but Kota is probably the younger of the two series (Sitholey, 1954). Plant bearing strata assigned to the Rajmahal, Kota, and Jabbalpur series occur widely scattered in several parts of India. The Kota series to which the plant-bearing rocks at Vemavaram are assigned, is developed in the Godavari valley south of Chanda and its outcrops are seen in several other localities along the East Coast of India.

Since this is the first record of microfossils from the East Coast Gondwanas of India it would be interesting to compare and correlate the present microflora with those from Rajmahal Hills (Vishnu Mittre, 1954) and Andigama (Sah, 1953). The microflora from Andigama, according to Sah (1953) suggests a greater affinity with the Rajmahal series, than with the other divisions of the Indian Upper Gondwanas.

Even a cursory glance at the nature of the Microfossils from all these three localities would suffice to indicate the general richness and variety of the spores and pollen grains from the Vemavaram area. Moreover, albeit there is a sort of general resemblance between the microfossils from these three areas, it can be said that the general nature and composition of the microflora from the East Coast Gondwana rocks are easily distinguishable from the Rajmahal and Andigama floras. The coniferous pollen is relatively more abundant in the Vemavaram microfossils compared to those from the Rajmahal series. Even the cuticular pieces, despite meagre is their evidence in the present case, all appear to be coniferous and the cycadophytic cuticles are conspicuous by their absence. This is more or less in keeping with the fact that in the Rajmahal series cycadophytes predominate, while the majority of the plant fossils in the Kota stage belong to the coniferæ. One-winged pollen grains have not been represented in the microflora of the Rajmahal series (Vishnu Mittre, 1954; Sah, 1953) while they are found in the present microflora. The author is not definite about the affinity of these one-winged grains, but their presence in the microflora of the Kota series seems to be highly interesting and decidedly of cer-

tain stratigraphical importance. Remains of the lycopods have not been discovered from the outcrops of the Kota stage, but the presence of many microspores resembling those of *Lycopodium* and even *Selaginella* shows that the lycopodiaceous element was probably not foreign to the flora of the Kota stage. While the evidence of the present microflora is not sufficient to throw any light on the relative ages of the Kota and Rajmahal series it, however, confirms the age assigned to the Vemavaram shales. Jurassic flora from the Tabbowa beds in Ceylon, according to Seward and Holttum (1922), shows a close affinity with the fossils of the Kota stage. In the light of the present work, if microfossils could also be recovered from the Tabbowa beds and also from the other localities of the East Coast Gondwana rocks, it would be of an added interest and importance to the stratigraphy of these outcrops.

Summary

Microfossils from a carbonaceous shale from Vemavaram in the East Coast Gondwana rocks of India have been described for the first time. Microspores and pollen grains are profusely represented, the former are mostly pteridophytic and the latter chiefly consist of coniferous and Ginkgoalean and to some extent Bennettitalean elements. Besides these, the microflora also includes some coniferous cuticles and wood fragments. Comparisons have been made with the microfossils from the Rajmahal series.

Acknowledgements

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EXPLANATION OF PLATES

PLATE X

FIGS. 1–28 *Microspores*

FIG. 1. *Lævigatisporites* Type 1, ×375.

FIG. 2. *Lævigatisporites* Type 2, ×375.

FIG. 3. *Lævigatisporites* Type 3, ×375.

FIG. 4. *Lævigatisporites* Type 5, ×375.

FIG. 5. *Punctatisporites* Type 1, ×375.

FIG. 6. *Punctatisporites* Type 2, ×375.

FIG. 7. *Camptosporites* Type 1, ×375.

FIG. 8. *Periplecosporites* Type 1, ×375.

FIG. 9. *Periplecosporites* Type 2, ×375.

FIG. 10. *Apiculatisporites* Type 1, ×338.

FIG. 11. *Apiculatisporites* Type 2, ×338.

FIG. 12. *Apiculatisporites* Type 3, ×338.

FIG. 13. *Tuberculatisoporites* Type, 1 ×338.

FIG. 14. *Tuberculatisporites* Type 2, ×450.

FIG. 15. *Setosisporites* Type 1, ×488.

FIG. 16. *Reticulatisporites* Type 1, ×375.

FIGS. 17, 18. *Reticulatisporites* Type 2, ×375.

FIG. 19. *Reticulatisporites* Type 3, ×375.

FIG. 20. *Reticulatisporites* Type 4, ×375.

FIG. 21. *Reticulatisporites* Type 5, ×375.

FIGS. 22, 23. *Piliferosporites* Type 1, ×375.

FIGS. 24, 25. *Striatotuberculatisporites* Type 1, ×375.

FIG. 26. *Litratisporites* Type 1, ×540.

FIG. 27. *Lævigatimonoletes* Type 1, ×375.

FIG. 28. *Lævigatimonoletes* Type 2, ×375.

FIGS. 29–30. *One-winged pollen grains*

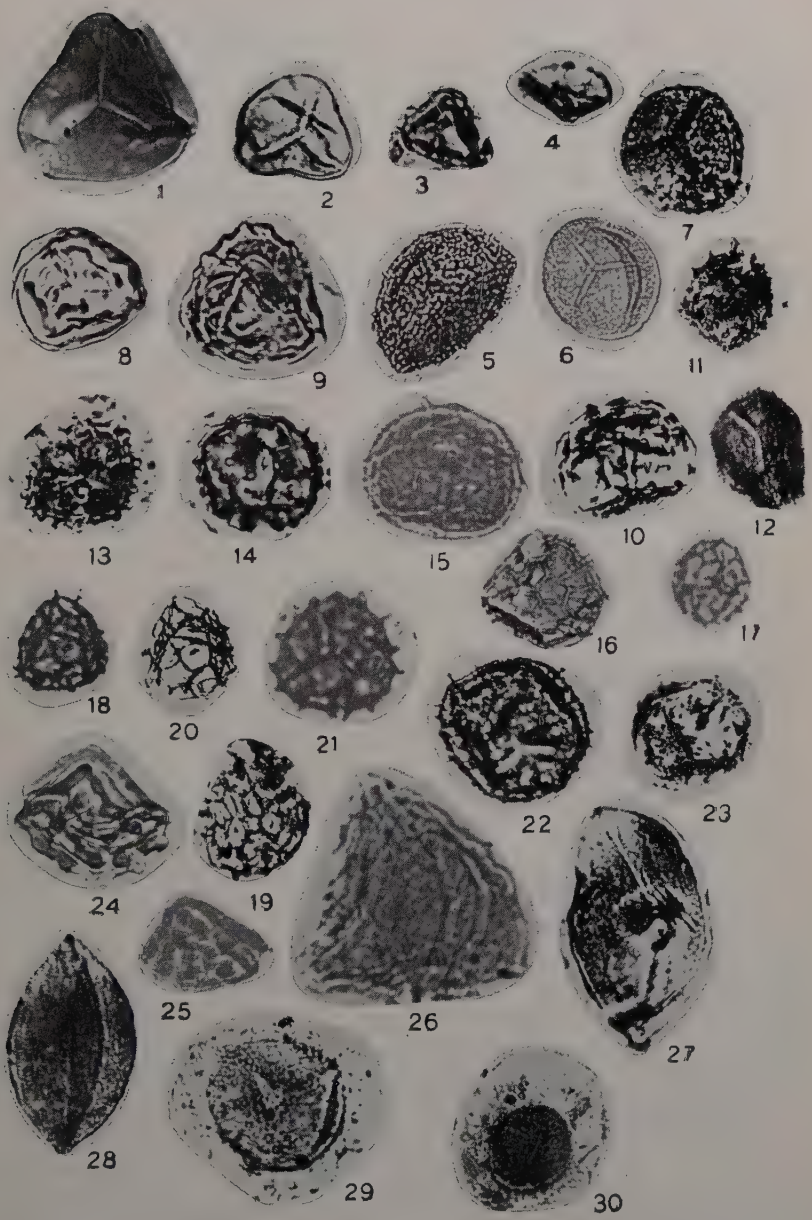
FIG. 29. One-winged grain (*Florinites*?). Note the vestigial trilete mark, ×375.

FIG. 30. Another one-winged grain. ×375.

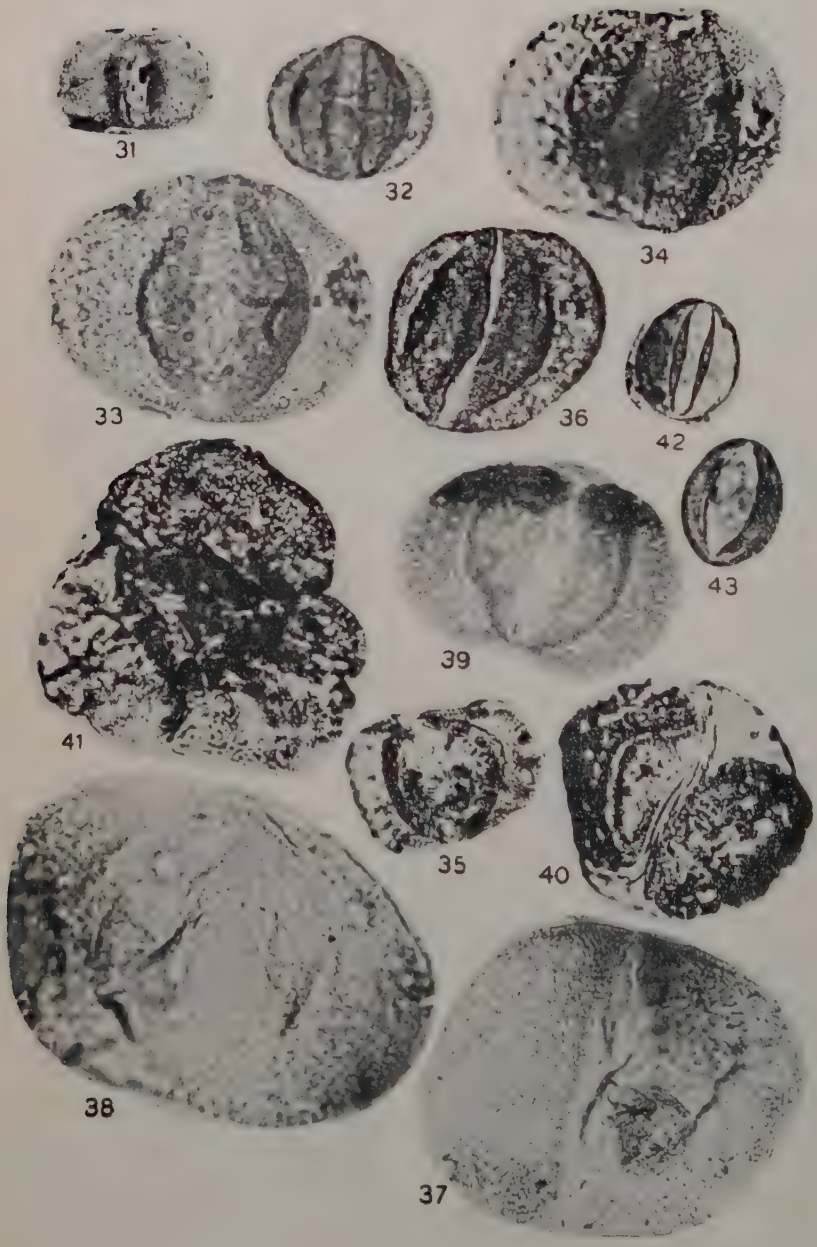
PLATE XI

FIGS. 31–43. *Pollen grains*

FIG. 31. *Alisporites* Type 1, ×375.
FIG. 32. *Alisporites* Type 2, ×375.
FIG. 33. *Alisporites* Type 3, ×375.
FIG. 34. *Alisporites* Type 4, ×375.
FIG. 35. *Alisporites* Type 5, ×375.
FIG. 36. *Alisporites* Type 6, ×375.
FIG. 37. *Alisporites* Type 7, ×488.
FIG. 38. *Alisporites* Type 8, ×420.
FIG. 39. *Pityosporites* Type 1, ×375.
FIG. 40. *Pityosporites* Type 2, ×375.
FIG. 41. *Podosporites* Type 1, ×540.
FIG. 42. *Entylissa* Type 1, ×375.
FIG. 43. *Entylissa* Type 2, ×375.



C. G. K. Ramanujam



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OBSERVATIONS ON THE ANATOMY, CYTOLOGY, DEVELOPMENT OF THE REPRODUCTIVE STRUCTURES, FERTILIZATION AND EMBRYOLOGY OF *PELVETIA CANALICULATA* DCNE. *ET* THUR.*

Part III. The Liberation of Reproductive Bodies, Fertilization and Embryology †

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Introduction

In this final part of the account on *Pelvetia canaliculata*, the remaining aspects of its life-cycle—liberation of the reproductive bodies, fertilization of the ova and the segmentation of the zygote to form the sporeling and the growth of the same to form the adult plant—are dealt with. It may be mentioned here that our knowledge of these aspects of the life-cycle of the members of the Fucaceæ is rather meagre and there appears to be no complete account for any one species. The results of a detailed study on these aspects of the life-cycle of one of the Fucaceæ are reported in this account.

Particulars relating to the material and methods are given in Part I of this series (Subrahmanyan, 1956).

Liberation of the Reproductive Bodies and its Periodicity

In *Pelvetia canaliculata* the liberation of the reproductive bodies begins at the end of July or the beginning of August and lasts till early September. During this period, an examination of the plants on the shore after the tide had been out for some hours, showed small whitish sticky masses of material extruded out of almost all the conceptacles in the ripe receptacles occurring on the plant. This is all the more pronounced if the plants had been left exposed for some time during daytime. Such plants were brought to the laboratory (Marine Biological Station, Port Erin), which is only a few yards from the shore, and placed in a large tray and covered with candle-filtered sea-water. The extruded mass either left the osteole of the conceptacle and sank to the bottom of the tray where it spread out, or dripped little by little from the osteole, the mass reaching the bottom often being in contact

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with that left over at the osteole or with the osteole itself by means of a thread of mucilaginous substance. The 'thread' is by no means firm and often it has been observed to dissolve out before reaching the bottom. It is permissible to assume that the products of all the conceptacles present on the plants are not liberated simultaneously and liberation may begin at different times, a fact certainly depending on the maturity and possibly on external factors also. They are, no doubt, set free into the cavity of the conceptacle first. If the plants are under water when liberation of reproductive bodies takes place, they are set free into the medium as they come out of the conceptacles. But, in *Pelvetia*, as far as it could be judged from observations, this does not appear to be the case. The products appear to come out when the plants are not under water and they accumulate at the osteole of the conceptacle. The duration for which they are thus exposed before they are covered by the tide again, will depend on the time when the liberation actually begins. The products are, therefore, exposed to the air to varying degrees and the consistency of the mucilage enclosing them will become denser with the duration of exposure owing to loss of water.

At the osteole itself, this loss of water may not be great as the extruded mass sticks out and covers it. In such instances as these, the whole mass sinks to the bottom when covered with water as the dissolution of the mucilage is quicker in this region of the opening; and, in instances where liberation had only just begun, the products drip to the bottom. During this process of liberation, only one oogonium is likely to pass out of the osteole at a time, as will be evident from a comparison of the size of the oogonium with the diameter of the osteole (Subrahmanyan, 1957, Pl. XII, Figs. 7 and 8). They come out accompanied by several antheridia and with a large quantity of mucilage.

We have to examine next how the contents of the conceptacles, oogonia and antheridia, come out of the osteole. It has already been mentioned that the reproductive bodies appear to come out when the plants are not under water. Inside the conceptacles, at first the oogonia and antheridia come to lie free after they are ripe. The oogonia are seen detached from the lining of the conceptacle and the antheridia from the stalk cell or the paraphyses on which they are borne. In what manner this is accomplished could not be determined. The antheridia do not appear to leave any trace behind and in the case of the oogonia, an "empty" space more or less corresponding to their shape was often seen in sections of the conceptacles.

The observations carried out on the fruiting plants of *Pelvetia* from the last week of June to the middle of September 1946, throw some light on the liberation of the reproductive bodies. The plants were examined almost daily on the shore as well as in the laboratory at Port Erin where some were brought for observation every time.

The first signs of liberation of reproductive bodies were noticed in the second week of July, the plants showing tiny sticky masses, extruded

out of the conceptacles, consisting of oogonia and antheridia. Fertilization was also observed. Continuous observations kept on plants *in situ* and on those brought to the laboratory, till the end of September, showed liberation of reproductive bodies occurring at fortnightly intervals and taking place when the plants were liable to be covered by the tides and a period of exposure helped their extrusion; however, when the conditions obtaining on the shore were simulated in the laboratory, by leaving the plants exposed for several hours and then covering them with sea-water, though this did bring about extrusion of these bodies, the latter were found to be immature and no fertilization could be observed. But similar experiments, carried out at the same period when liberation was taking place in plants on the shore, brought about extrusion of normal reproductive bodies and fertilization also took place. Extrusion of immature reproductive bodies under artificial conditions has also been recorded by Farmer and Williams (1898, p. 629).

The peak period for extrusion of reproductive bodies is seen to be August–September (*cf.* also Subrahmanyan, 1948 *a*, *b*). Towards the end of the period, the receptacles on the plants begin to turn yellow and then orange in colour and show signs of degeneration.

The more or less regular interval observed between the dates of the actual liberation of reproductive bodies was striking. Such a phenomenon appears to have been recorded hitherto only for the submerged members of the Fucales (Sauvageau, 1912; Tahara, 1909, 1913, 1927, 1929 *a*, *b*; and Moser, 1929) and *Himanthalia* (Gibb, 1937). Williams (1905) has recorded such a periodicity in *Dictyota dichotoma*. The record of such a periodicity in *Pelvetia canaliculata* led to an examination of the tide chart. It was found that the actual dates of liberation coincided with the period of the spring tides. The actual extrusion is preceded by several hours of exposure and the liberation of the bodies into the water takes place when the tide covers the plants during daytime. Plants were examined on the same dates after the tide had receded having covered them once, and till about 9 P.M. there were no signs of further extrusion on the plants on the same day.

It may be interesting to recall here that *Pelvetia* is not covered by neap tides generally and, therefore, it is understandable that, for the progeny to survive, liberation of the reproductive bodies must take place when the plants are under water to facilitate fertilization, etc. The observations lead to the inference that, in the majority of plants, liberation takes place during the period of spring tides when alone the plants become completely submerged as they grow so high up on the shore, and that, the reproductive bodies being in a ripe state, a number of hours of exposure (even as it occurred in the laboratory) brings about the extrusion of them at the osteole. It is not altogether improbable that, when the reproductive bodies are ripe in the conceptacles, a contraction of the thallus, resulting from exposure, helps this process. Baker (1910, p. 12) states that for the maximum liberation of reproductive bodies in species growing at higher levels on the shore, a longer period of exposure is necessary.

Further, observations on individual plants marked on the shore during the reproductive season and on this phenomenon of extrusion of reproductive bodies in more or less fortnightly intervals which synchronize with the spring tides would suggest that two or more crops of reproductive bodies are produced inside the conceptacles; as one set reaches maturity, another is probably only half mature and still another crop is presumably in the process of initiation. Sections of conceptacles examined have confirmed this view; they show reproductive bodies, oogonia and antheridia, in all stages of development.

Fertilization

Observations on the Living Material

The liberated mass containing oogonia and antheridia was kept under observation in a hollowed glass slide. Immediately after liberation, the oogonia and antheridia showed the same condition that obtained inside the conceptacle in the ripe state. Several antheridia were also seen liberated along with the stalk or paraphyses on which they occur. The oogonia appeared more or less like the one shown in Pl. XIII, Fig. 9 (Subrahmanyan, 1957) in external appearance.

Within a short time, the spermatozoids began to escape from the antheridia. The thin membranous wall enclosing them appears to gelatinise or just dissolve away at one end—the upper end, as seen in instances where the antheridium was still attached to the paraphyses—and the contents flow out resembling in a way the flow of the contents of an egg when opened and poured out. Soon the mucilage-like matrix in which they appear to be lying, dissolves in the water and the spermatozoids swim about. They are somewhat pear-shaped and very active, show two cilia, one long and one short, the latter directed forwards, a red eye-spot or stigma near the region of the attachment of the cilia; and, on very close examination, a pale yellowish body inside, probably a chromatophore (Text-Fig. 1, *sp*). The spermatozoids swim towards the oogonia and hundreds of them have been seen aggregated near the equatorial region of the oogonium. The writer is unable to agree with the statement of Thuret (1878, p. 46) that the spermatozoids of *Pelvetia* lack an eye-spot. Oltmanns (1889) does not describe the spermatozoids of this alga in his account.

The changes that follow in the oogonium on liberation are more gradual and take time. At first, a swelling occurs leading to the increase in volume of the oogonium as such; this swelling appears to concern the peripheral region of the oogonial wall which at this stage is jellylike (Pl. XII, Fig. 1). Next, the protoplast inside each half of the oogonium recedes from the equatorial region as well as from the wall around, and simultaneously with this, a further increase in the volume of the oogonium is effected by the two halves of the oogonial wall separating and receding from each other; and at this stage only some faint lines are noticeable at the equator of the oogonium. Meanwhile, the ova have rounded themselves off. Synchronizing with the rounding off of the ova and the separation of the two hemispherical halves of the

oogonium wall, there is a forcible rush of water with the spermatozoids in it into the oogonial chamber, and sometimes even tiny bits of debris sticking to the oogonium in this region or floating nearby are also taken in (Pl. XII, Figs. 2 and 3). It looks as though a vacuum is created, inside the oogonial chamber, due to the rounding off of the ova and also by the increase in the volume caused by the swelling of the oogonial wall and the separation of the halves, thus leading to the drawing in of the outside medium in which spermatozoids are found in hundreds and more in the immediate vicinity of the oogonium itself. It is possible that other factors not obvious now are also involved in this process. After this *rush* during which hundreds of spermatozoids are drawn in, other spermatozoids have been observed to enter the oogonial chamber through the equatorial region, swimming in of their own accord apparently. There appears to be no obstruction to their entry.

The spermatozoids swim very actively around the ova but do not succeed in rotating them as the spermatozoids of *Fucus* are known to do. The ova show some shaking movements occasionally, probably due to the impact on it of the numerous spermatozoids. The spermatozoids swim lashing their cilia, come very near the periphery of the ova and some stop. When closely examined, these were found stuck to the surface of the ova by their long cilium, the short one still lashing or vibrating. The pointed end of the spermatozoid thus attached, was directed away from the surface of the ovum. It appears that "sitting" in this posture, with the broad end on and the pointed end away, the short cilium vibrating and the long one holding on, the spermatozoid works its way into the ovum. Four instances of actual entry of the spermatozoid were observed, in three of which the pointed end was the last to disappear into the ovum; in the fourth instance, owing to an accident, the spermatozoid was lost from view and the last stages could not be followed. The time taken from the beginning of the attachment to the disappearance of the spermatozoid into the ovum was less than two minutes. In many instances, the entry of the spermatozoid was not observed, though they were seen attached to the surface of the ovum and continued to show activity for a long time. Possibly, the ova in these instances had already been fertilized. It is not possible to say how many spermatozoids enter each ovum in this manner, for, the one that was being watched had to be kept under observation continuously.

The size of the ova varies from 111 μ to 137 μ in diameter; the majority being over 120 μ. The ovum is surrounded by a thin membrane which appears to offer a little resistance to the entry of the spermatozoid, as evidenced by the struggle of the latter to enter the ovum. The ovum is very dense in contents and by focussing properly, a lighter area could be distinguished at the centre, probably occupied by the nucleus. In about an hour, the ovum surrounds itself with a clear wall and the spermatozoids still seen inside the oogonium die (Text-Fig. 1).

It cannot be stated whether the spermatozoids of the same plant or from the same conceptacle fertilized the ova or whether the spermatozoids were from other plants. *Pelvetia* is a hermaphrodite; and, as

far as observations go, no precedence in the liberation of either sexual product could be established; both oogonia and antheridia are liberated simultaneously and it is not improbable that spermatozoids from the same conceptacle bring about fertilization often.

Levring (1947, p. 98) states that eggs of Fucaceæ are always known to be naked. After conducting certain experiments on the eggs of *Fucus spiralis* and *F. vesiculosus*, he has established that the eggs are covered with a thin membrane, designated the "egg-membrane", not directly visible under the microscope. The writer had no difficulty in establishing the presence of a membrane in *Pelvetia canaliculata*. The appearance of this membrane was very similar to that shown in Pl. XII, Fig. 6. This membrane is clearly visible in the living material as a thin refractile line surrounding the ova and appears to offer a little resistance to the entry of the spermatozoid as stated already.

It may be of interest to mention here that in *Pelvetia canaliculata*, Thuret (1854, p. 210) saw only the spermatozoids glistening on the surface of the ova. Oltmanns (1889, p. 93) observed the entry of the spermatozoids into the oogonium through the mucilage at the equatorial region and believed that a fusion of the spermatozoids with the ova took place. In *Halidrys*, Farmer and Williams (1898, pp. 633–34) describe certain interesting changes in the external appearance of the ova during fertilization, but they also do not appear to have observed the actual entry of the spermatozoid into the ovum. No clear instance of the entry of the spermatozoid into the ovum, as described here for *Pelvetia* by the writer, appears to have been recorded before for any member of the Fucales.

The Oogonial Wall.—Before proceeding to describe the changes that take place inside the fertilized ovum, the writer would like to add here a few remarks concerning the wall of the oogonium of *Pelvetia canaliculata*. According to Thuret (1878, p. 46), the oogonium (*dispore*) leaves the "exochite" (*perispore*) and the latter is seen inside the conceptacles as the "empty sporangium". The writer has observed all the stages depicted by Thuret (1878, Pl. XXII, Figs. 9, 11, 12 and 13) for *Pelvetia*, but was unable to establish the "empty sporangium" (*Sporange, vide* Thuret, *op. cit.*, Pl. XXII, Fig. 10) though numerous preparations of the receptacles in all stages of development were closely examined for such a possible occurrence. Only empty spaces were seen inside the conceptacles. Delf (1935, p. 246) refers to *Pelvetia* oospheres being enclosed after extrusion from the "exochite". The writer's observations show that the *whole* oogonium is detached in the process of extrusion.

On being liberated into water, the wall of the oogonium swells and exhibits very striking series of changes which appear to be peculiar to this alga. It is very difficult to describe the structure of the wall with the conventional terms, such as exochite, mesochite and endochite, as there appear to be more than three layers to be accounted for.

There is an outermost layer bounding both the ova together; this layer rapidly gelatinizes in sea-water and gives way more particularly in the equatorial region. It may be seen sometimes, several hours after fertilization, persisting in varying degrees. This may be compared with the *perispore* of Thuret (1854) and exochite of other authors. It is possible that the "empty sporangium" seen by Thuret might be due to the appearance presented by the gelatizination of this layer when the oogonium was still inside the conceptacles and the contents alone escaping out leaving this layer behind.

After the gelatinization of the outermost layer, the following layers of wall could be distinguished in each half of the oogonium which has now the appearance of two cups without handles, one inverted over the other. From the periphery inwards, the order is (Text-Fig. 1): (1) an outermost thin membranous layer *a* which covers the rest of the layers on all sides, not going across the oogonial chamber but ending near its circumference, so that there is no partition of the oogonial chamber; (2) a thick layer *b* which looks like a padding between *a* and *c*, and is jelly-like in appearance (stains well with methylene blue and gentian violet); (3) a tough conspicuous layer *c*, and (4) a thin membrane innermost, *d*, which lines both halves of the oogonial chamber. The line *r* in the figure represents the circumference of layer, *c*, this being omitted in the upper half for the sake of clarity. The layers *a*, *b* and *c* appear as though slipped over *d*.

The membrane *d* appears to hold together the two halves of the oogonium. This layer does not offer any resistance to the current of water which enters the chamber when the two halves tend to separate and the ova round up; may be, it gives way in some places, but this is difficult to be determined owing to its extreme hyaline nature. In a few instances, the two halves have been seen to fall back during the rush of liquid inwards (Pl. XII, Fig. 3). Usually four or five hours after fertilization, there is no trace of this layer at all.

The membrane *a*, after some hours, is lost or it may be seen between the two oogonial halves like two rings placed adjacent to each other; in the latter instance, no trace of it could be seen over the halves of the oogonium. It is likely that it gets ruptured by the swelling of the layers *b* and *c*.

Text-Fig. 2 and Pl. XII, Fig. 4 show the appearance of the oogonial wall, about three to four hours after fertilization of the ova had taken place. Sometimes this appearance is presented earlier or at times later; *p*, represents the attachment region of the oogonium to the conceptacle lining; *r'*, the circumference line of the layer *c* (shown in Text-Fig. 1). The layers *b* and *c* appear to have split themselves and four thickened layers of wall can be seen clearly marked *1*, *2*, *3* and *4* respectively. It is not possible here to determine which of the layers originally represented *b* and which *c*. Gentian violet stains the structures better than methylene blue. The layers *1* and *2* are rather deeply stained, and *3* moderately and *4* poorly; the spaces between the layers hold the stain more conspicuously than the layers themselves and

probably they contain mucilage. A closer examination reveals transverse striation in the inner two layers. Progressively, the outer layers become fainter, presumably due to gelatinization, and in about 36 to 48 hours, generally, there is only one, rather tough-looking layer left which persists for some time and is seen covering the developing embryo.

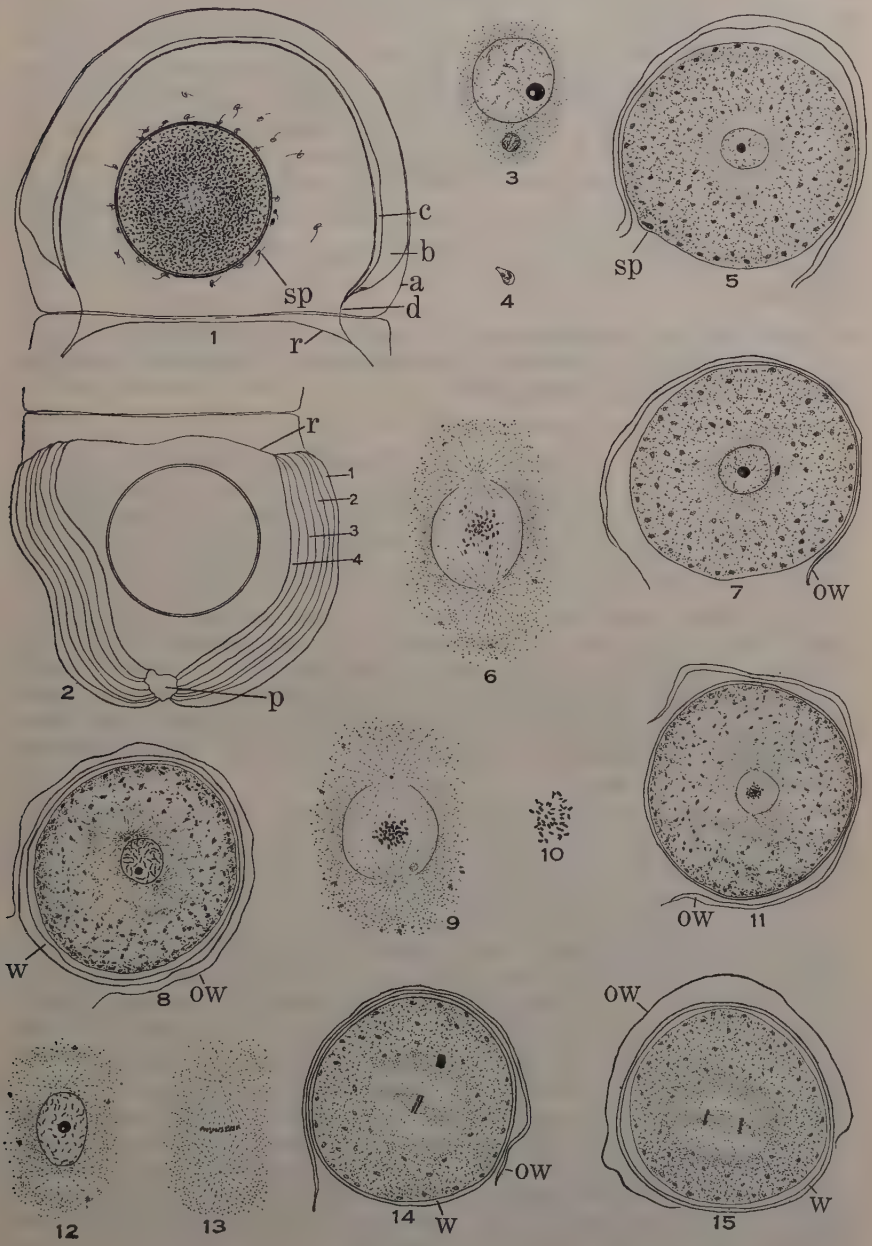
The outermost layer which gelatinises away quickly may correspond to the *perispore* or *exochite*; the layer *b* to be *epispore* or *mesochite* and the layer *c* to *la membrane interne qui revet immediatement les spores* or *endochite* of Thuret and other authors, respectively (*op. cit.*). Evidently, they have overlooked the membranes *a* and *d* noticed by the writer; these two membranes are distinguishable only on very close examination as they are somewhat hyaline. Thuret (1854, p. 207) states that he obtained cellulose reaction for the *perispore* but not for the *epispore* or the inner layer and the wall of the ovum also gave cellulose reaction.

Oltmanns (1889, p. 87) states that when the oogonium is brought into the sea-water, the different layers of the wall swell. According to him, there is an outer structureless layer and then, inside, a second layer which exhibits a stratification parallel to the surface on the one hand and radial on the other; the latter gives the impression that this aspect may be due to the radial arrangement of closely set rods. These remarks of Oltmanns have been fully borne out by the observations of the writer, but neither Oltmanns nor Thuret recorded the membranes observed by the writer, as also the separation of the inner portion, layers *b* and *c*, to form four distinct layers. It may be mentioned here that Resühr (1935) describes the mesochite of *Fucus vesiculosus* as being complex and consisting of four layers; and, in *Scytothalia dorycarpa*, Naylor (1949) states that the middle swollen region of the oogonial wall is a much more complex structure than the mesochite of *Fucus*. The similarity of these observations to those on *Pelvetia canaliculata* described here is worth noting.

The observations also revealed that there is no transverse wall or partition between the two ova. The latter, after rounding up, float inside the oogonial chamber in a mixture of sea-water and mucilage, as is evidenced by the lightly stained nature of the oogonial chamber. The absence of a transverse wall is also confirmed by observations on fixed and stained material. Oltmanns (1889, p. 84) speaks of a thin partition wall between the ova; the writer is unable to confirm this. For a study of the structure of the wall of the oogonium, living material appears to be the best, for, the thickness and mucilaginous nature of the wall hinders smooth sectioning, as the wall tends to crumble when microtomed in these stages.

The complicated oogonial wall is very sticky and helps attachment of the developing embryo to the substratum. The thick nature of the same and its persistence until the embryo attains considerable development and is able to attach itself by rhizoids, show that it discharges a protective function as well, besides playing a rôle in bringing about fertilization, as already described, by drawing in the medium

in which spermatozoids are found; obviously, these adaptations are very necessary to this plant growing at such a high level on the shore and getting exposed for very long periods. Often the neap tides do



TEXT-FIGS. 1–15

TEXT-FIGS. 1–15. *Pelvetia canaliculata.* Fertilization and segmentation divisions in the zygote. Fig. 1. Fertilized ovum inside oogonial chamber; some spermatozoids seen inside; for explanation of oogonial wall layers, see text. Fig. 2. Shows appearance of the oogonial wall after the oogonium had been in sea-water for some hours. For detailed explanation, see text. Fig. 3. Male nucleus near nucleus of the ovum; note increased size of former. Fig. 4. Spermatozoid; note nucleus, chromatophore (?) and stigma. Fig. 5. Ovum with spermatozoid just inside its membrane. Figs. 6–9 and 11. Early metaphase from the I segmentation division of the zygote; note centrosomes, nucleolus and persisting nuclear membrane. Fig. 7. Ovum with spermatozoid near its nucleus. Figs. 8 and 12. Zygote; prophase of I segmentation division; note centrosomes in Fig. 8. Figs. 10 and 13. Metaphase of I segmentation division; polar view in Fig. 10. Figs. 14 and 15. Early anaphase of I segmentation division of the zygote. *a*, *b*, *c*, *d*, *r*, in Fig. 1 and *1*, *2*, *3*, *4*, *r'* in Fig. 2: layers of the oogonial wall; explanation in text. *p*, attachment portion of the oogonium to conceptacle wall; *sp*, spermatozoid; *ow*, oogonial wall; *w*, wall of embryo. (Figures 1 and 2, from living material, ×170; Figs. 3, 4, 6, 7, 9, 10, 11, 13, ×723; and Figs. 5, 8, 12, 14 and 15, ×500).

not cover the *Pelvetia*-zone; only the spring tides reach the zone and it is interesting that the period of extrusion of reproductive bodies synchronizes with the spring tides.

Observations on Fixed and Stained Material

The spermatozoid shows the same structure as when seen in the living condition, except that there appears to be a little shrinkage to its body and that the cilia appear to have dropped off. It is pear-shaped, shows a small nucleus with a nucleolus, a lightly stained body (chromatophore?) and a darkly stained eye-spot (Text-Fig. 4).

The ovum stains very densely. It possesses numerous chromatophores and is rich in granular substances. The thin membrane bounding it is very clearly seen. At the centre of the ovum, a large nucleus with a prominent nucleolus is conspicuous. The nucleolus sometimes shows vacuolations. The reticulum in the nucleus is well stained, when compared with the condition while the ovum is inside the oogonium within the conceptacle.

The material, fixed at short intervals during the observations on the fertilization, was sectioned for the study of the nuclear changes taking place inside the ovum and the zygote. The stages in the process of union of the spermatozoid with the nucleus of the ovum are represented in Text-Figs. 3, 5 and 7 and in Pl. XII, Figs. 6, 7 and 8. In Text-Fig. 5 and in Pl. XII, Fig. 6, the spermatozoid *sp* is seen just within the membrane of the ovum. Owing to the denseness of the contents of the ovum, it was not possible to follow the course of the spermatozoid through the body of the ovum to its nucleus. In Text-Fig. 7 and Pl. I, Fig. 7, the spermatozoid is seen lying close to the nucleus of the ovum. Before actual fusion, all that could be distinguished of the spermatozoid inside the ovum is a smaller nucleus which is seen lying close to the large nucleus of the ovum; and, finally, a fusion of nuclei is effected (Text-Fig. 3; Pl. XII, Fig. 8). The male nucleus gradually merges into the female nucleus and this is witnessed by the denseness of the chromatin matter at one place inside the nuclear cavity of the female nucleus in the next stage observed. All these stages were seen

in material fixed shortly after fertilization was observed in the living material.

The actual fusion between the spermatozoid nucleus and that of the ovum has been observed only in a few of the Fucales, *viz.*, *Fucus vesiculosus* (Farmer and Williams, 1896, p. 483; 1898, Pl. XXI, Figs. 20–23; Strasburger, 1897, p. 362, Pl. XVIII, Figs. 24–29), *Coccophora langsdorfii* (Tomita, 1932, pp. 44–45) and *Sargassum tortile* (Abé, 1938, p. 254).

Embryology

Segmentation of the Zygote

The stages in the segmentation of the zygote were studied with the aid of cultures. Soon after fertilization, the nucleus of the zygote begins to show signs of division. Material fixed about two hours after fertilization showed plenty of prophase stages and that fixed at subsequent intervals showed all the stages. The large size of the nucleus in the zygote facilitates a detailed study of the mitotic division in this alga.

The nucleus even at the time of fertilization was not in a typical resting state, but showed a rather well-stained reticulum. During prophase, thin chromosomal threads become evident in the nucleus and two centrosomes also become visible at opposite poles accompanied by the characteristic radiations in the cytoplasm (Text-Fig. 8). The chromosomes progressively become deeply stained (Text-Fig. 12) and at metaphase, tend to arrange themselves at the equator of the spindle which appears to be intra-nuclear (Text-Figs. 11, 9, 13 and 10; Pl. XIII, Figs. 9 and 10). The nuclear membrane persists, but it is not visible at the two poles where the centrosomes, if present, are to be seen. The nucleolus may also sometimes be seen at this stage (Text-Figs. 9 and 11). The visibility of the centrosomes appears to depend on the plane of the section and the proximity of the plane to the nucleus. Sometimes, only one of them is seen, obviously the section is oblique; or, if the section passes at right angles to the axis of the spindle it may be difficult to make out the centrosomes from the numerous other dark granules present. In subsequent divisions, they have been seen once or twice, but not always. There is no doubt, however, about the presence of centrosomes in *Pelvetia*. After anaphase (Text-Figs. 14, 15 and 16; Pl. XIII, Fig. 11) and telophase (Text-Fig. 17) two daughter nuclei are organized. In polar views of metaphases of this division, 44 (2 *n*) chromosomes were counted (Text-Fig. 10).

While these nuclear changes could be seen in the zygotes fixed at intervals up to 8 hours after fertilization, the division of the protoplast was not obvious till after 24 hours. How cytokinesis is actually effected is not clear. As far as the present observations go, it appears that, in the actual laying out of the septa, the cytoplasmic radiations mentioned by Farmer and Williams (1898, p. 639, Pl. XXIII, Figs. 36, 37 and 39) and also seen by the writer, may have a rôle. According to Rosenvinge (1889) the first wall during the ova segmentation in this

alga is laid out perpendicular to the direction of light. The writer's observations confirm those of Rosenvinge in this respect. Portions of the oogonial wall persist until a very late stage in the development of the embryo (Text-Figs. 7, 8, 11, 14, 15, 16, 17, 18 and 20, *o.w.*).

After the protoplast has divided into two (Text-Figs. 18 and 20), the segments undergo further division, the division of the nucleus preceding that of the cytoplasm (Text-Figs. 19 and 21; Pl. XIII, Fig. 12). Forty-eight hours after fertilization, four-celled embryos become common in the cultures. The cells divide again (Text-Figs. 23, 22, 25 and 26) and on the fifth day, the embryo consists of a mass of cells (Text-Fig. 24). On the same day, the beginnings of rhizoid formation also become evident (Text-Fig. 30). The rhizoids arise from one end of the embryo. In the cultures, it was found that the end away from the source of light produced the rhizoids (Pl. XIII, Figs. 13 and 14). The rhizoids are formed in *fours at first*‡ and they grow out as papillæ from the cells situated at the appropriate end and are later cut off by cell walls (Text-Fig. 29). As they grow further, their cells divide by transverse partitions (Text-Figs. 31, 32 and 34).

Already at this stage, in median sections, one could distinguish a more or less regular layer of close-fitting cells at the periphery, the meristoderm (Text-Figs. 27, 28, and 29, *me*). There is as yet no organization of tissues inside, only a uniform mass of cells is to be seen. The plane of division of the cells, shown in Text-Fig. 22, indicates how this peripheral layer of cells is cut off (*cf.* also Text-Figs. 26, 27 and 28). This peripheral layer actively divides anticlinally and periclinally, adding respectively to the surface of the thallus and to the tissue inside.

In a few instances, the embryos showed rhizoids at two poles (Text-Figs. 33 and 36). Presumably, this is brought about by a mechanical disturbance of the orientation of the embryo in relation to light. Another peculiarity is shown in Text-Fig. 37, where, in one embryo, rhizoids are developed in two sets.

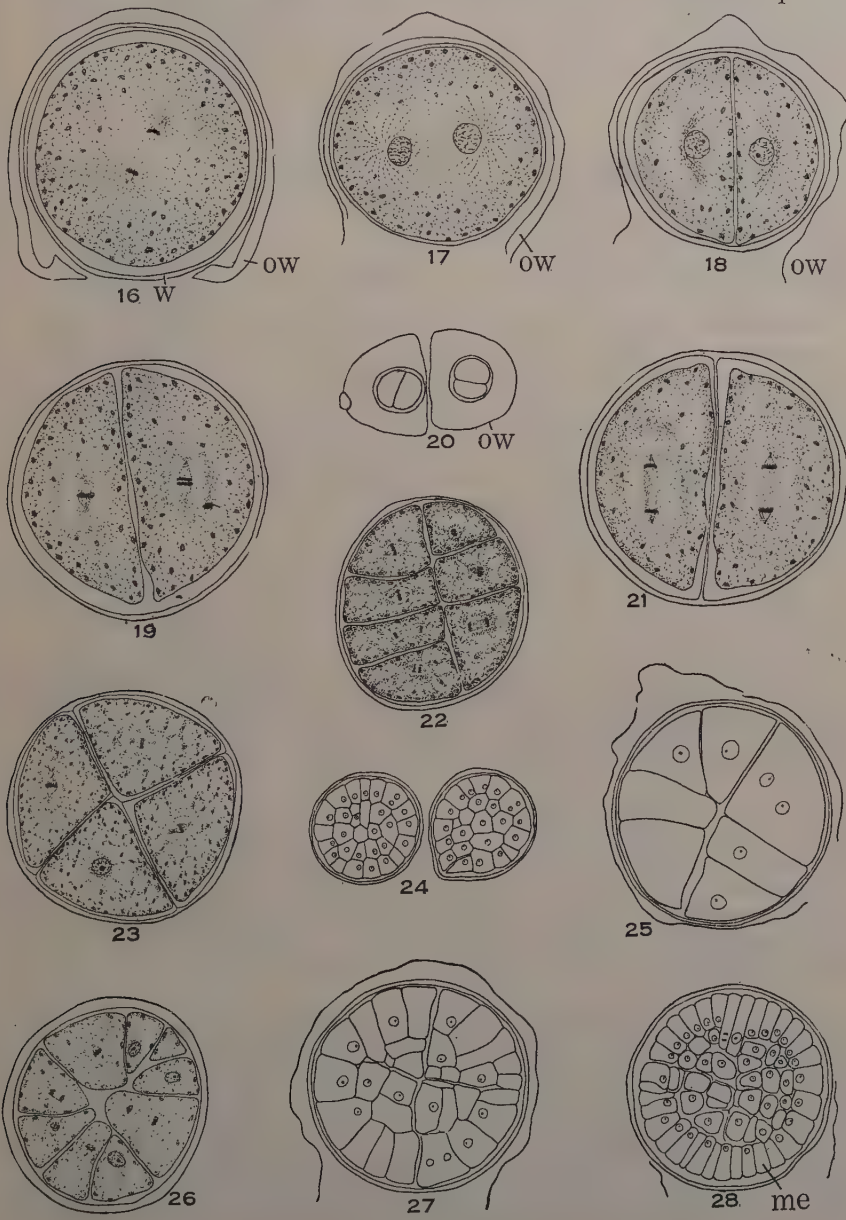
The Sporeling

In Text-Figs. 32 and 34 are shown 3-week old sporelings. They are still rounded and the rhizoids have grown longer and begun to branch (Text-Fig. 34). The cells at the surface of the thallus show plentiful yellowish brown chromatophores. Sections show that the cells inside also possess chromatophores and a prominent nucleus. The whole thallus appears to carry on assimilation. The meristoderm has been more clearly differentiated and there have been additions to the tissue inside. The rhizoid cell also shows a number of chromatophores, a prominent nucleus and two globular bodies (?) on either side of the nucleus (Text-Fig. 44).

In the course of the fourth week, the sporelings began to lengthen. Until this stage, it was not possible to distinguish a transverse section

‡ The significance of this will be referred to further below.

from a longitudinal one unless the section happened to include the rhizoids also; but, from now on, such a distinction could easily be made. At the end opposite to the rhizoid-bearing region, a cell with dense cytoplasm and a prominent nucleus but with no chromatophores



TEXT-FIG. 16–28

TEXT-FIGS. 16–28. *Pelvetia canaliculata*. Segmentation division in the zygote and anatomy of the embryo. Fig. 16. Late anaphase of I segmentation division in the zygote. Fig. 17. Telophase of I segmentation division. Figs. 18 and 20. Two-celled embryos; latter shows embryo inside oogonial wall; embryo 1½ days old. Figs. 19 and 21. Division in the 2-celled embryo; note nuclear figure. Fig. 23. Four-celled embryo; cells dividing further. Figs. 22, 25 and 26. Further divisions in the cells of the embryo. Fig. 24. Five days old embryo; note rhizoid beginning to grow out. Figs. 27 and 28. Multicellular embryo; note compact outermost layer, the meristoderm. *w*, wall of embryo; *ow*, oogonial wall; *me*, meristoderm. (Figures 16 and 17, ×500; Figs. 18, 19 and 21, ×333; Fig. 20, ×54; Figs. 22, 23, 25 and 26, ×286; Fig. 24, ×140; and Figs. 27 and 28, ×233.)

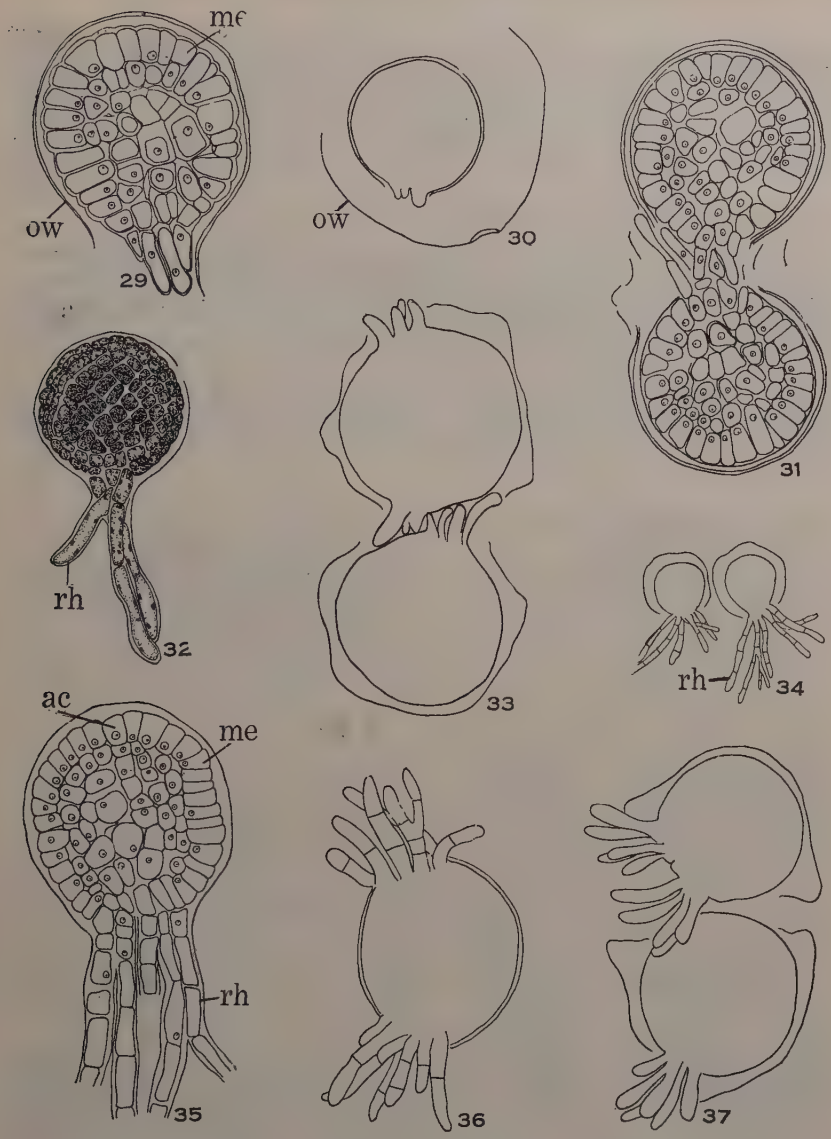
now becomes recognizable, the *apical cell* (Text-Fig. 35; Pl. XIII, Fig. 15). The apical cell is seen a little sunk and appears to be a modified cell of the meristoderm. In transverse sections, the apical cell is three-sided (Text-Fig. 41). The activity of this cell leads to the growth in length of the thallus and the latter becomes cylindrical (Pl. XIII, Fig. 14).

When the cultures were examined again, the sporelings had grown to about 600 μ in length, and were still cylindrical in appearance. Sections of these sporelings showed the beginnings of differentiation of the three tissues, meristoderm (this had already become differentiated earlier), cortex and medulla (Text-Figs. 38 and 40). The cortex may be only of a single layer of cells; the medullary elements begin to show lengthening and some development of mucilage (Text-Fig. 43). Transverse sections of sporelings at this stage nearer the base show only the peripheral layer of meristoderm cells and some medullary elements scattered at the centre (Text-Fig. 42). A section of a six-month old sporeling (Text-Fig. 39) shows that differentiation of tissues has advanced further and these tissues resemble more and more those seen in the larger individuals. As yet there is no branching.

The cultures of the sporelings did not survive the severe winter of 1947, as the culture medium froze. In order to complete the story, therefore, the sections of tiny plants obtained from the shore were studied. Plants of all ages are easily obtained from the shore.

One striking difference between the sporelings in the cultures and those of similar appearance obtained from the shore, concerned the rhizoids. In the cultures, the rhizoids had grown to enormous lengths, often several times longer than the sporeling itself (Pl. XIII, Fig. 14). But, the sporelings from the shore showed that the rhizoids had spread and formed a holdfast (Text-Fig. 45). In all other respects the sporelings of similar sizes agreed in their anatomy.

After the sporelings had attained a size of 3–5 mm. they began to show branching. The apical cell henceforward, in sections, is not so sharply three-sided as it was before, but is more or less four-sided. The thallus also begins to undergo flattening, the differentiation of tissues becomes more marked and development of mucilage pronounced. Sections, longitudinal and transverse, nearer the base of the plants measuring 1 cm. in size, reveal strikingly elongated cells (Pl. XIII, Figs. 17 and 18). Among the medullary cells, several tiny cells are to be seen cut transversely. It appears as though these elongated cells spread

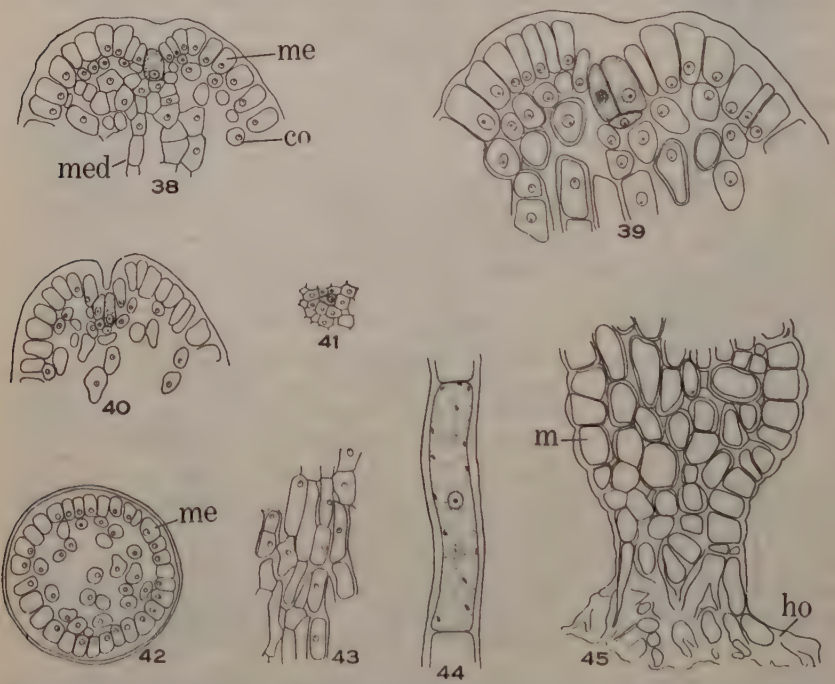


TEXT-FIGS. 29–37. *Pelvetia canaliculata.* Embryo, rhizoid formation and early differentiation of tissues. Fig. 29. *L.s.* of an embryo; note rhizoids and slight differentiation of tissues, meristoderm, *me*, mass of cells inside the cuticle. Fig. 30. Five days old embryo; beginnings of rhizoid; note also oogonial wall. Drawn from living specimen. Fig. 31. Multicellular embryo; rhizoids developed in the embryos very close to each other; such embryos may grow so close to each other that in the adult stage what appears as one plant may be really two. Fig. 32. Three weeks old embryo; living specimen; note chromatophores in the cells. Fig. 33. Embryos; note in one of them, rhizoids at two poles. Fig. 34. Three weeks old embryos; rhizoids well developed; oogonial wall still seen. Drawn

from living specimen. Fig. 35. Embryo showing compact meristoderm and early differentiation of an apical cell at the pole opposite the rhizoids; note long-branched rhizoids. Fig. 36. Embryo with rhizoids at two poles. Drawn from living material. Fig. 37. Embryos; in one rhizoids developed in two sets. Drawn from living material. *me*, meristoderm; *ow*, oogonial wall; *ac*, apical cell; *rh*, rhizoid. (Figures 29, 31, ×233; Fig. 34, ×54; Fig. 35, ×140; and the rest, ×170.)

out and reinforce the attachment to the substratum. Perhaps a few hyphæ are produced near the region of attachment at this early stage itself. With the further activity of the apical cell, the sporeling grows and the thallus attains its characteristic form and also develops the characteristic channel. The details of the anatomy of the mature plant have already been dealt with (Subrahmanyan, 1956).

The sequence of development of the thallus to attain the characteristic nature is interesting: before differentiation of the apical cell, the activity of the meristoderm differentiated by the segmentation



Text-Figs. 38–45. *Pelvetia canaliculata*. Anatomy of the sporeling. Fig. 38. *L.s.* of sporeling not long after differentiation of apical cell; note tissues. Fig. 39. *L.s.* of young sporeling slightly older than former; note segments cut off by the apical cell; the nucleus in one segment is in late prophase (lateral segment). Fig. 40. *L.s.* of another very young sporeling, earlier than former two. Fig. 41. *T.s.* of apex of sporeling, about 4 weeks old, showing apical cell, three-sided. Fig. 42. *T.s.* of young sporeling. Fig. 43. Medulla of young sporeling in *l.s.* Fig. 44. Cell from a rhizoid. Fig. 45. Basal portion of a young sporeling from the field; note holdfast. *me*, meristoderm; *co*, cortex; *med*, medulla; *ho*, holdfast. (Figure 39, ×500; and the rest, ×233.)

of the zygote and of the other cells, leads to the formation of a spherical thallus, which, in growth, increases in diameter; with the differentiation of the three-sided (in sections), four-faced, apical cell, the thallus grows in length as well and becomes cylindrical; and, with the differentiation of the four-sided (in sections), five-faced, apical cell, the thallus begins to show the adult features.

Discussion

Early Development.—It would be of interest to review here some of the former observations on the early development of this alga. Thuret (1878, Pl. XXIII, Figs. 14–16) gives some illustrations of the embryo while it is still inside the oogonial wall. Oltmanns (1889, pp. 24–29) confirms Thuret's observations and deals with the anatomy of the sporeling; the writer's observations agree with those of Oltmanns and add many details to it. Oltmanns has not figured the early stages nor has he recorded the nuclear divisions during the segmentation of the zygote.

Inoh's (1935, pp. 13–14) account of the embryology of *Pelvetia wrightii* appears to resemble that of *Fucus* (Farmer and Williams, 1896; Oltmanns, 1889; and Nienburg, 1931). After the first segmentation in the zygote, one of the cells protrudes out and this portion is cut off by a cell wall. This forms a rhizoid cell. In *Pelvetia canaliculata*, rhizoid formation begins only after the embryo has become multicellular and, to begin with, four rhizoids arise from one end. A definite rhizoid initial is not distinguishable; but the constancy of their number renders it probable that in the multicellular embryo, at some stage, in all normal instances, a few cells, four in *P. canaliculata*, are set apart for this purpose. It may be mentioned here that a large number of species in the Sargassaceæ has been investigated in this regard and the number of rhizoids produced in them was found to vary with the species; so characteristic is this feature that species have been assigned to 4-, 8-, 16-, and 32-celled types (Tahara, 1913, 1928, 1929 *b*; Okabe, 1929; Inoh, 1930, 1932). It is interesting to note that *P. canaliculata* resembles closely *Cystophyllum hakodatense* (Inoh, 1932) which has been assigned to the four-celled type in the Sargassaceæ.

Origin of the Apical Cell.—In *Pelvetia canaliculata*, no hairs are produced in connexion with the differentiation of the apical cell in the embryo; in other words, the apical cell is not trichothallic in origin. In *Fucus* (Nienburg, 1929, 1931), the differentiation of the apical cell is associated with the formation of hairs at the apex of the embryo, at the pole opposite the rhizoid-bearing one; the basal cell of the first-formed hair is constituted into the apical cell, the remaining cells withering off. The writer has also observed hairs at the apical region of the embryo in connexion with the differentiation of the apical cell in *Fucus spiralis* (unpublished). Delf (1939, p. 229) states in a discussion on the vegetative structure of the Fucales, that evanescent apical hairs have been recorded for other genera of the Fucales than *Fucus vesiculosus*, and cites *Pelvetia* as one example and refers to Oltmanns (1889). Naylor (1951, p. 513) also cites Oltmanns as having reported apical

tuft of hairs on the sporelings of *Pelvetia*. Oltmanns (*op. cit.*), in his account of *Pelvetia canaliculata* sporeling, does not refer to the presence of apical hairs in the alga (*cf.* also Fritsch, 1945, p. 349). The following relevant passage from Oltmanns (*op. cit.*, p. 27) will clarify the point: "*Die Scheitelgrube enthält hier keine Haare, was nicht befremden kann, da* Pelvetia *ja auch niemals auf seinem Thallus Haargruben producirt.*" Referring to the older plants Oltmanns states: "*Die Scheitelspalten von* Pelvetia *enthalten an alteren Pflanzen ebenso wenig wie an den jüngeren Haare, indess findet man hier meist einen eigenartig aussehenden Schleim, der zuweilen aussieht wie verschleimte Zellen, über dessen Herkunft und Bedeutung ich mir aber keine Klarheit verschaffen konnte.*" The presence of mucilage in the apical furrow has already been referred to by the writer when dealing with the anatomy of the thallus (Subrahmanyan, 1956). This mucilage is of a very thick consistency and often shows lamellations which feature, perhaps, led Oltmanns to suggest a gelatinization of cells here whose origin and significance he could not clarify. It appears to the writer that this mucilage is formed in the furrow in the same manner as the mucilaginous cuticular layer covering the surface layer of cells, the meristoderm, presumably by secretion; only, that in the apical furrow is very thick and lamellated which, evidently, is a great protection to the apical cell situated at the bottom of the furrow. It can be categorically stated that nowhere in the thallus of *Pelvetia canaliculata* are hairs produced at any stage in its life-history and the only hair-like structures found in this alga, the paraphyses, occur inside the conceptacles.

Concluding Remarks

Certain very striking points emerging from this study on *Pelvetia canaliculata* may be briefly recounted here.

In the organization of the plant body, this alga exhibits special adaptations shown by the profuse development of mucilage within the thallus and the thick lamellated cell walls, which when compared with the organization of the Fucales growing at different levels on the shore in which production of mucilage and thickness of the cell walls are not as conspicuous as in *Pelvetia*, indicate how eminently suited is the thallus of this alga to conditions prevailing at a higher habitat on the shore where plants are left exposed for very long intervals, often days. In other words, production of mucilage and thickening of the cell walls appear to decrease gradually as one examines the different species of the Fucales inhabiting the shore from the highest levels downwards, so much so, the completely submerged members tend to show more or less a parenchymatous structure of their thallus.

In the development of the conceptacle, *Pelvetia canaliculata* differs from all the other Fucales. The transverse division of the initial cell, observed in the other species, is completely suppressed here and the conceptacle initial inaugurates a succession of anticlinal divisions to give rise to the conceptacle. The transverse division to form the lining tissue of the conceptacle is postponed until the conceptacle chamber is well

differentiated. The alga represents an advance in this respect over all the members of the Class investigated so far.

In the production of two ova in the oogonium, in the absence of partition walls in the antheridium, in the release of reproductive bodies when the plants are likely to be covered by the tides and in the retention of the ova within the oogonium during fertilization, the alga is unique among the members of the Class.

The structure and organization of the oogonial wall are significant. It plays a rôle in ensuring fertilization of the two ova; its swelling and consequent increase in volume cause a current of water containing spermatozoids to rush into the oogonial chamber. Its extremely sticky nature affords an initial attachment to the embryo; and, portions of the wall persist in varying degrees until the embryo develops rhizoids and is able to secure attachment for itself. It is well known that *Pelvetia* is not often covered by the neap tides; since the spring tides alone cover the vegetation, the duration of immersion is short owing to the higher habitat on the shore; it is, therefore, obvious that if *Pelvetia* eggs were to be liberated out of the oogonium they will have very little chance of survival. The complex organization of the oogonial wall appears to be another special adaptation correlated to the higher habitat.

It is striking that in the production of four rhizoids during the early development, *Pelvetia* shows an affinity with the Sargassaceæ.

Summary

1. In this account of *Pelvetia canaliculata*, the following aspects are dealt with in detail: the liberation of reproductive bodies and its periodicity, the structure of the ovum, spermatozoid and the oogonial wall, the mode of fertilization, the development of the zygote and the sporeling, leading to the adult features of the plant.

2. A periodicity was noticeable in the liberation of the reproductive bodies related to the higher (spring) tides. This appears to be the first record of such a phenomenon in any Fucaceæ growing in the intertidal zone.

3. The spermatozoid is pear-shaped, shows an eye-spot, a lightly stained body (chromatophore?) and a nucleus. Two cilia are seen on each in the living state. They are not colourless when examined in the living condition, as reported to be the case by earlier authors.

4. The ovum is large, spherical and is bound by a thin refractile membrane; possesses a large number of chromatophores and a prominent nucleus; and is rich in granular substances.

5. Fertilization was observed to take place within the oogonium. The entry of the spermatozoid into the ovum is described, as also the fusion of the male and female nuclei.

6. A detailed description of the complex oogonial wall is given. It was found to have a rôle in effecting fertilization. The early

development of the embryo takes place inside the oogonial wall which persists in varying degrees for quite a considerable time.

7. The segmentation of the zygote, early development of the embryo and the anatomy of the sporeling are described in detail.

8. Centrosomes were observed during the mitotic division of the zygote nucleus.

9. The number of chromosomes observed during the division of the zygote nucleus was estimated to be 44 (2 *n*). All stages of the mitotic division have been recorded.

10. In the production of four rhizoids in the embryo, *Pelvetia canaliculata* shows an affinity to the Sargassaceæ.

11. The origin of the apical cell and its rôle leading to the characteristic growth of the thallus are described. The apical cell in this alga is not trichothalic in origin, as is the case in several of the Fucaceæ. Some errors that have crept into the literature in this regard are pointed out.

12. Several adaptations and advances which this alga exhibits are discussed.

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EXPLANATION OF PLATES

PLATE XII

FIG. 1. A discharged oogonium. Note early swelling of the oogonial wall. Photomicrograph of living specimen, ×378.

FIG. 2. Oogonium with two ova rounded up, oogonial wall separated and numerous spermatozoids inside. Photomicrograph of living specimen, ×144.

FIG. 3. Oogonium with two ova. Note oogonial wall pushed apart by the inrushing fluid (explanation in text). Photomicrograph of living specimen, ×144.

FIG. 4. Oogonium with fertilized ova. Note several layers of oogonial wall (explanation in text). Photomicrograph of living specimen, ×144.

FIG. 5. Oogonium with two normal ova and two aborted ova (smaller bodies). Photomicrograph of living specimen, ×144.

FIG. 6. Fertilization: section of oogonium (only a portion shown) showing spermatozoid, *sp*, inside an ovum, just within the ovum membrane, ×1,503.

FIG. 7. Fertilization: male nucleus spermatozoid, *sp*, near nucleus of ovum, ×1,467.

FIG. 8. Fertilization: male nucleus lying close to nucleus of the ovum just before fusion. Note increased size of male nucleus, *sp*, ×1,467.

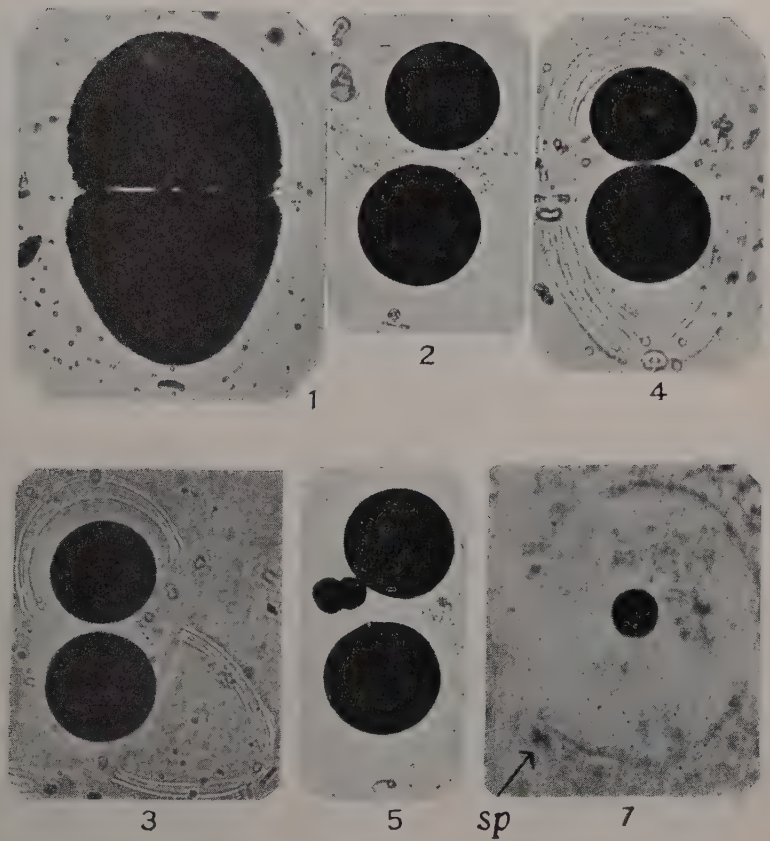
PLATE XIII

FIG. 9. First segmentation division of the zygote: nucleus in metaphase, ×435.

FIG. 10. The same; nuclear figure in 9 magnified. Note intra-nuclear spindle, astral radiations from the poles of the spindle, ×1,008.

FIG. 11. Anaphase of nucleus during the I segmentation division of the zygote, ×1,008.

FIG. 12. Metaphase; nuclear figure from division of a 2-celled embryo, ×1,008.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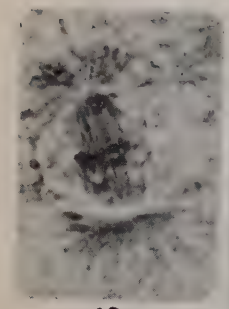
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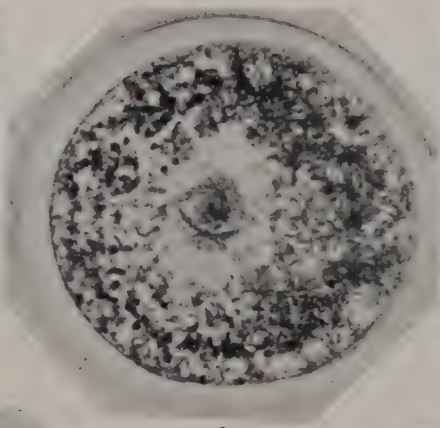
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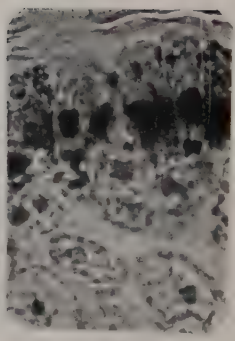
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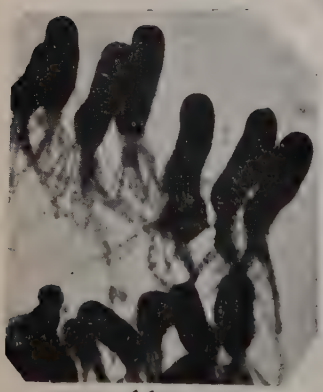
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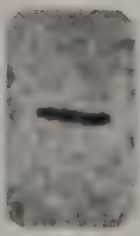
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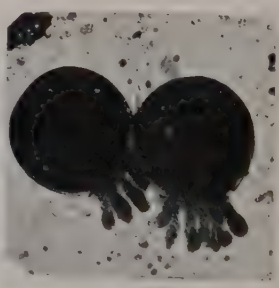
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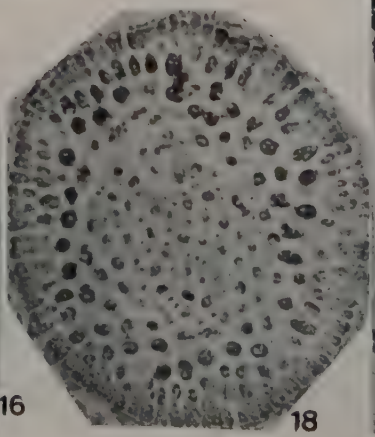
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FIG. 13. Embryos with beginnings of rhizoids. Photomicrograph of living specimen, ×*circa* 450.

FIG. 14. A few of the 6-month old sporelings from culture. Note sporelings oriented in one direction, the rhizoids away from the source of light, also the long multicellular rhizoids, ×33.

FIG. 15. *L.s.* of sporeling, 4 weeks old, showing apical cell, ×450.

FIG. 16. *L.s.* of sporeling in which apical cell had been functioning for sometime. Note presence of chromatophores in all cell, ×121.

FIG. 17. *L.s.* of basal portion of the thallus of very young plant (about 1 cm. size); note elongated cells near the base, ×149.

FIG. 18. *T.s.* of a very young plant near the base. Note at the centre small cells cut among larger ones, probably hyphæ (?) near the base to reinforce attachment, ×113.

STUDIES IN THE HYDROPHYTES OF UMRED

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Introduction

The author, in one of his earlier contributions (1954), has drawn attention to the neglect of the systematic study of the flora of Nagpur and its neighbouring areas. This is particularly true of the aquatic and marsh vegetation of this region. The author's own findings about the hydrophytes of Nagpur have already been published in this Journal.

It is now intended to present here an account of the floristic composition and distribution of the hydrophytes of Umred. The author had the opportunity of visiting this place a number of times during 1955–56 and the following pages give a fairly comprehensive data about the water and marsh plants of the area.

Umred lies on 20° 51′ 10″ N. latitude and 79° 19′ 28″ longitude. It is situated at a distance of about twenty-nine miles to the south-east of Nagpur. Its height above sea-level is 948 feet. There is a fertile soil derived from the weathering of basaltic rocks which are exposed at places. It is black in colour. At other places, we get the light-coloured soil which might have been derived from the metamorphic rocks that are found in this area. Umred has a climate which is not much different from that of Nagpur. There is an average annual rainfall of about fifty inches. This is received mostly during the months June to September. The temperature may reach a maximum of 115° F. in the month of May.

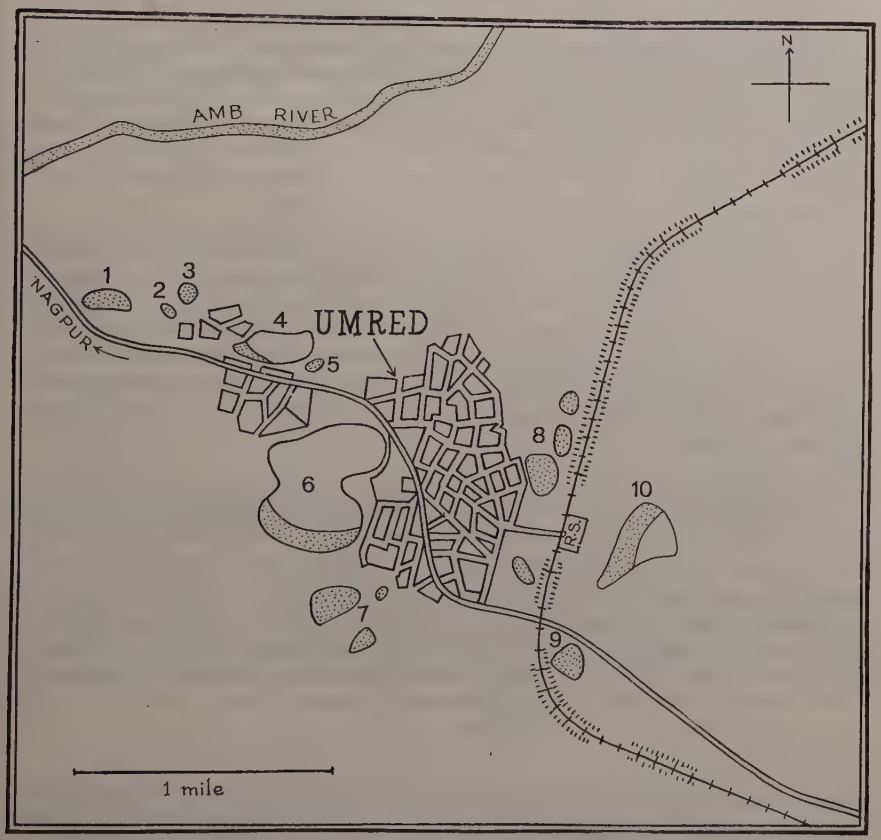
Habitats

The habitats of hydrophytes distributed round about Umred are shown in the map (Text-Fig. 1). They comprise some perennial lakes which hold water throughout the year, ponds which may dry up during hot season and a number of temporary puddles and ditches that get filled up with water during the rainy season but dry up soon by the end of December.

I. *Lakes*

These show a luxuriant growth of the aquatic and marsh vegetation. As the water recedes from the sloping banks towards the deeper central region with the march of the dry season, the hydrophytic flora of these habitats shows an interesting zonal distribution. The gently sloping marginal zone exhibits a characteristic carpet vegetation, the

shallow middle zone covered with water during the rainy season and getting gradually exposed during the winter, supports a rich and varied marsh vegetation, while the central zone, which is always under water, is favourable for the growth of a number of floating and deep water forms. These lakes are utilized for extensive cultivation of *Trapa bispinosa* Roxb. during the rainy season.



TEXT-FIG. 1. Map showing the habitats of hydrophytes. 1. Munara Talao, 2. Munda Talao, 3. Maroti Talao, 4. Knart Talao, 5. Bhavani Talao, 6. Bada Talao, 7. Pingala Talao, 8. Hara Talao, 9. Dabhira Talao, 10. Gopalram Talao.

(i) *Munara Talao*.—Being situated a little away from the "basti", this lake is comparatively free from biotic influences. The water is occasionally disturbed by the fishing nets and by the cattle that are bathed in it. Further, the lake is of recent origin. Some six years ago it was only a low-lying area. This was converted into a lake by reecting an artificial earthen dam on one side. There is a rich hydrophytic vegetation comprising about forty species. A noteworthy feature of geographical interest is the very abundant growth of *Isœtes*

coromandelina Linn. which is restricted to this habitat only. It has not been able to spread out to any of the neighbouring lakes or ponds. Among other species which are found here, but which have rather restricted distribution in Umred, mention may be made of *Blyxa roxburghii* Rich., *Limnanthemum indicum* Thwaites., *Utricularia stellaris* Vahl., *Butomopsis lanceolata* Kunth. and *Eriocaulon truncatum* Buch-Ham.

(ii) *Khari Talao.*—This is a large lake situated in the " basti ". It is under the biotic influence not only on account of extensive cultivation of *Trapa bispinosa* Roxb. but also because the waste and night soil of the neighbouring locality are freely carried into it. This results naturally in the luxuriant growth of nitrophilous species like *Eichhornia crassipes* Solms., *Ipomœa aquatica* Forsk. and *Eclipta prostrata* Linn. *Neptunia oleracea* Lour. is one of the rarer species of Umred found in this habitat.

(iii) *Bada Talao.*—This is the largest lake within the area under survey. On the side of the "basti" it is lined with masonry. The residents of the neighbourhood wash their clothes on this bank. A large portion of the tank is utilized for cultivation of *Trapa bispinosa* Roxb. in the rainy season. The lake shows a varied and abundant hydrophytic flora comprising about forty species. *Polygonum tomentosum* Willd. and *Potamogeton crispus* Linn. found here have restricted distribution in Umred.

(iv) *Gopalram Talao.*—This is again a huge reservoir of water. It is situated near the Umred Railway Station and quite removed from the city. It is, therefore, almost free from biotic influence and one can see here a rich hydrophytic vegetation in its natural undisturbed form. Besides more than thirty common species that inhabit this area, *Hydrolea zeylanica* Vahl., *Sesbania aculeata* Poir., *Jussiæa suffruticosa* Linn., *Sagittaria guayanensis* H.B. and K., *Bacopa monnieri* (Linn.) Pennell, *Lindernia ciliata* (Colsm.) Pennell and *Monochoria vaginalis* (Burm. f.) Presl. may be cited as some characteristic plants of this area.

II. *Ponds*

As pointed out earlier, these dry up in the hot season. The period for which they hold water may slightly vary from pond to pond. Most of these are almost completely choked with *Trapa bispinosa* Roxb. during the rainy season.

(i) *Munda Talao.*—This is a small depression near the Munara Talao described above. A large portion of it dries up soon after rainy season and supports several marsh and wetland species. Being less frequented by animals as well as human beings, it is almost undisturbed by biotic factors. While *Lemna minor* Linn., *Azolla pinnata* R. Br., *Aponogeton natans* Linn. and *Nymphæa stellata* Willd. are characteristic of the deep water zone, the shallow margins support a rich growth of *Limnophyton obtusifolium* Miq., *Limnophila heterophylla* Woodr., *Asteracantha longifolia* Nees. and *Ipomœa aquatica* Forsk. *Sphæranthus*

indicus Linn. and *Commelina benghalensis* Linn. thrive in pure stands on the drying muddy patches from which water has recently receded.

(ii) *Maroti Talao*.—This pond, situated in the vicinity of Munda Talao, shows a rich assemblage of water and marsh plants. During the monsoons and a few months later, it is under a huge crop of *Trapa bispinosa* Roxb. Besides this species, about twenty more plants thrive in and on the margins of this pond. They include extensive pure stands of *Eichhornia crassipes* Solms. and *Commelina benghalensis* Linn. growing on the shallow margins that form swampy areas. During the month of February, *Azolla pinnata* R. Br. forms huge masses on the surface. *Pistia stratiotes* Linn. may be mentioned as one of the rarer species of Umred occurring here.

(iii) *Bhavani Talao*.—This little pond is situated in the vicinity of the Khari Lake mentioned above. The hydrophytic vegetation of this pond, comprising about twenty-five species, resembles largely that of the Khari Talao in its floristic composition. *Rumex dentatus* Linn. and *Xanthium strumarium* Linn. occur here as wetland species along with *Melochia corchorifolia* Linn.

(iv) *Pingala Talao*.—The Bada Talao, described earlier, almost merges into the adjacent Pingala Talao. *Monochoria vaginalis* (Burm. f.) Presl., *Lobelia alsinoides* Lam., *Potamogeton indicus* Roxb., *Canscora decurrens* Dalz. and *Eriocaulon truncatum* Buch-Ham. are some of the characteristic members of the hydrophytic flora of this habitat, which, besides these species, shows a number of other aquatic and marsh plants that are found in and on the margins of the Bada Talao also.

(v) The Hara, Chhota and Dabhira Talaos are comparatively smaller ponds. They are largely devoted to the cultivation of *Trapa bispinosa* Roxb., besides which they show half a dozen other species including *Azolla pinnata* R. Br., *Eichhornia crassipes* Solms., *Pistia stratiotes* Linn. and *Naias minor* Allioni.

III. *Puddles*

These are a number of shallow bodies of water distributed throughout the area. They dry up almost immediately after the rainy season. *Asteracantha longifolia* Nees., *Sphæranthus indicus* Linn., *Eclipta alba* Hassk., *Ammania baccifera* Linn., *Cæsulia axillaris* Roxb., *Commelina benghalensis* Linn. and *Alternanthera sessilis* (Linn.) R. Br. are some representative species of such habitats. A notable feature is the occurrence of *Veronica anagallis* Linn. in pure stands at some restricted spots while it is conspicuous by its absence elsewhere. During the rainy season, when these depressions are holding considerable quantity of water, some of them show the growth of free floating species like *Azolla pinnata* R. Br., *Lemna minor* Linn., *Spirodela polyrhiza* Schleid., submerged forms like *Ceratophyllum demersum* Linn., *Hydrilla verticillata* Presl. and *Naias minor* All. as well as marsh plants like *Limnophyton obtusifolium* Miq., *Aeschynomene indica* Linn. and *Marsilea quadrifolia* Linn. along with *M. minuta* Linn.

Taxonomic Data

The aquatic and marsh vegetation of Umred comprises a rich and varied assemblage of vascular hydrophytes, besides a large number of algal forms including species of *Chara* and *Nitella*, which are usually found in association with the angiospermic submerged species. On the basis of the author's own collections, the following taxonomic data could be given for the vascular hydrophytes of Umred.

	Families	Genera	Species
Pteridophyta			
Isœtales ..	1	1	1
Hydropteridineæ ..	2	2	3
Angiosperms			
Dicotyledons ..	17	29	36
Monocotyledons ..	13	22	24

Floristic List

PTERIDOPHYTA

Isœtales

I. Isœtaceæ .. *Isætes coromandelina* Linn.

Hydropteridineœ

II. Marsileaceæ .. *Marsilea quadrifolia* Linn.
M. minuta Linn.

III. Salviniaceæ .. *Azolla pinnata* R. Br.

ANGIOSPERMS

Dicotyledons

I. Nymphæaceæ .. *Nymphæa stellata* Willd.
N. rubra Roxb.

II. Malvaceæ .. *Malachra capitata* Linn.

III. Sterculiaceæ .. *Melochia corchorifolia* Linn.

IV. Leguminosæ
Papilionatæ .. *Sesbania aculeata* Poir.
Aeschynomene indica Linn.
A. aspera Linn.
Mimosoideæ .. *Neptunia oleracea* Lour.

V. Lythraceæ .. *Ammania baccifera* Linn.
A. rotundifolia Ham.

VI. Onagraceæ .. *Jussiæa suffruticosa* Linn.
J. repens Linn.
Trapa bispinosa Roxb.

VII. Compositæ .. *Sphæranthus indicus* Linn.
Cæsulia axillaris Roxb.
Xanthium strumarium Linn.
Eclipta prostrata Linn.

VIII.	Lobeliaceæ ..	*Lobelia alsinoides* Lam.
IX.	Gentianaceæ ..	*Canscora decurrens* Dalz. *Limnanthemum indicum* Thwaites. *L. cristatum* Griseb.
X.	Hydrophyllaceæ	*Hydrolea zeylanica* Vahl.
XI.	Convolvulaceæ ..	*Ipomæa aquatica* Forsk.
XII.	Scrophulariaceæ	*Limnophila heterophylla* Woodr. *Lindernia crustacea* (Linn.) F. Mueli. *L. ciliata* (Colsm.) Pennell *Veronica anagallis* Linn. *Bacopa monnieri* (Linn.) Pennell
XIII.	Lentibulariaceæ	*Utricularia flexuosa* Vahl. *U. stellaris* Linn.
XIV.	Acanthaceæ ..	*Asteracantha longifolia* Nees. *Hygrophila polysperma* T. Anders.
XV.	Amarantaceæ ..	*Alternanthera sessilis* (Linn.) R. Br.
XVI.	Polygonaceæ ..	*Polygonum tomentosum* Willd. *Rumex dentatus* Linn.
XVII.	Ceratophyllaceæ	*Ceratophyllum demersum* Linn.

MONOCOTYLEDONS

XVIII.	Hydrocharitaceæ	*Hydrilla verticillata* Presl. *Lagarosiphon roxburghii* Benth. *Vallisneria spiralis* Linn. *Blyxa roxburghii* Rich. *Ottelia alismoides* (Linn.) Pers.
XIX.	Pontederiaceæ ..	*Eichhornia crassipes* Solms. *Monochoria vaginalis* (Burm. f.) Presl.
XX.	Commelinaceæ ..	*Commelina benghalensis* Linn. *Aneilema nudiflorum* Br.
XXI.	Araceæ ..	*Pistia stratiotes* Linn.
XXII.	Lemnaceæ ..	*Lemna minor* Linn. *Spirodela polyrhiza* Schleid.
XXIII.	Alismaceæ ..	*Sagittaria guayanensis* H.B. and K. *Limnophyton obtusifolium* Miq.
XXIV.	Butomaceæ ..	*Butomopsis lanceolata* Kunth.
XXV.	Aponogetonaceæ	*Aponogeton natans* Linn.
XXVI.	Potamogetonaceæ	*Potamogeton indicus* Roxb. *P. crispus Linn.*
XXVII.	Naiadaceæ ..	*Naias minor* Allioni *N. graminea* Del.
XXVIII.	Eriocaulaceæ ..	*Eriocaulon truncatum* Buch-Ham.

XXIX.	Cyperaceæ	.. *Cyperus* sp. *Scirpus* sp.
XXX.	Gramineæ	.. *Hygrorhiza aristata* Nees.

Ecological Classification

The hydrophytes of Umred can be classified into the following six life-forms on the basis of their contacts with soil, water and air.

(A) *Floating hydrophytes.*—These are in contact with water and air only. While *Trapa bispinosa* Roxb., *Hygrorhiza aristata* Nees. and *Ipomæa aquatica* Forsk. occur in pure stands, the following communities are very characteristic of the floating vegetation of several lakes and ponds.

Azolla-Spirodela-Lemna community

Eichhornia-Pistia community

Neptunia oleracea-Jussiæa repens community.

(B) *Suspended hydrophytes.*—These are rootless, submerged hydrophytes that are in contact with water only, *e.g.*, *Ceratophyllum demersum* Linn. This species has been found to grow in shallow waters, often leading to the complete exclusion of other water plants. The Utricularias have their vegetative organs suspended in water, but their inflorescences are aerial.

(C) *Anchored submerged hydrophytes.*—These are entirely, or for the most part, in contact with soil and water only. In some of these, *e.g.*, *Naias graminea* Del. and *N. minor* All., even the flowers are completely submerged. Others, like *Hydrilla verticillata* Presl., *Vallisneria spiralis* Linn. and *Blyxa roxburghii* Rich., have their vegetative shoots under water, but the flowers are raised to or slightly above the surface of water. Species of *Hydrilla*, *Vallisneria* and *Blyxa* occur in pure stands.

(D) *Anchored hydrophytes with floating leaves.*—These are in contact with the soil, water as well as air. Here are included species like *Aponogeton natans* Linn., *Nymphæa stellata* Willd., *Limnanthemum cristatum* Griseb. and *L. indicum* Thwaites, which possess only the floating leaves, as well as *Sagittaria guayanensis* H.B. and K. and *Ottelia alismoides* (Linn.) Pers., which are heterophyllous.

(E) *Emergent amphibious hydrophytes.*—The root, the lower part of the stem and, in some cases, even the lower leaves of these hydrophytes are usually submerged under water. *Aeschynomene indica* Linn., *A. aspera* Linn., *Sesbania aculeata* Poir., *Hygrophila polysperma* T. Anders. and *Limnophyton obtusifolium* Miq. are some of the characteristic species of this group. *Limnophila heterophylla* Woodr. shows well marked heterophylly. Several of these species form very extensive pure stands.

(F) *Wetland hydrophytes.*—These are rooted to the soil that is usually saturated with water, at least in the early part of their life. The

category includes a large number of species of the Umred flora. *Malachra capitata* Linn., *Ammania baccifera* Linn., *Veronica anagallis* Linn., *Polygonum tomentosum* Willd., *Sphæranthus indicus* Linn. and *Commelina benghalensis* Linn. are some representative members of this class of hydrophytes. Some of them continue to thrive even after the substratum has considerably dried up.

Discussion

1. The foregoing account of the floristic composition of the hydrophytes of Umred shows that the aquatic and marsh vegetation of the locality includes a number of angiospermic plants, besides a few pteridophytes. They include both primitive (*e.g.*, Nymphæaceæ, Alismaceæ, Butomaceæ) and advanced families (*e.g.*, Compositæ, Gramineæ) of the dicotyledons as well as of the monocotyledons.

2. The accompanying table indicates the relative range of distribution of the various species. As many as twelve species show a restricted distribution, being confined to one or two habitats only. Mention may be made particularly of *Isætes coromandelina* Linn., *Potamogeton crispus* Linn. and *Sagittaria guayanensis* H.B. and K. On the other hand, *Eclipta prostrata* Linn., *Limnophyton obtusifolium* Miq., *Commelina benghalensis* Linn. and *Trapa bispinosa* Roxb. are very widely distributed. The last species owes its wide distribution to its extensive cultivation by the inhabitants of the place. Water level and the period for which the low-lying areas hold water seem to control the distribution of most species. The occurrence of *Isætes coromandelina* Linn., which is known to grow in soils poor in mineral salts (Arber, 1920, p. 287), and of the nitrophilous species of *Eichhornia*, *Ipomæa*, *Neptunia* and *Utricularia* is, obviously, further determined by the edaphic factors.

3. It is significant to note that some hydrophytes, occurring quite abundantly at Nagpur, twenty-nine miles away, are characteristically absent here. Mention may be made of *Cleome chelidonii* Linn., *Hygrophila quadrivalvis* Nees., *Typha angustata* Bory and Chaub. and *Potamogeton pectinatus* Linn., among others. On the other hand, *Isætes coromandelina* Linn., *Aeschynomene aspera* Linn., *Neptunia oleracea* Lour., *Jussiæa repens* Linn., *Hydrolea zeylanica* Vahl., *Limnanthemum indicum* Thwaites, *Blyxa roxburghii* Rich., *Sagittaria guayanensis* H.B. and K. and *Butomopsis lanceolata* Kunth. of the Umred flora have not been reported to occur in the vicinity of Nagpur.

4. One of the chief problems, confronting those dealing with the floristic composition, distribution and adaptations of the vascular hydrophytes, particularly, is the delimitation and scope of the term "hydrophyte".

Weaver and Clements (1938) define hydrophytes as "plants that grow in water, in soil covered with water, or in soil that is usually saturated with water".

Muenscher (1944) interprets aquatic plants as "those species which normally start in water and must grow for at least a part of their

Table showing the detailed distribution of hydrophytes in the various habitats of Umred

Lakes.—L_1—Munara, L_2—Khari, L_3—Bada, L_4—Gopalram.
Ponds.—P_1—Munda, P_2—Maroti, P_3—Bhavani, P_4—Pingala, P_5—Hara, P_6—Chhota, P_7—Dabhira.
Puddles.—M—Miscellaneous ditches, etc.

Species	Habitats											
	Lakes				Ponds							Puddle
	L_1	L_2	L_3	L_4	P_1	P_2	P_3	P_4	P_5	P_6	P_7	M
1. *Aeschynomene aspera* Linn.		×		×		×						
2. *Ae. indica* Linn.	×	×	×	×		×	×	×				×
3. *Alternanthera sessilis* (Linn.) R. Br. ..	×		×									×
4. *Ammania baccifera* Linn.	×		×					×				×
5. *A. rotundifolia* Ham.	×											×
6. *Aneilema nudiflorum* Br.	×											×
7. *Aponogeton natans* Linn.	×		×	×	×	×		×				
8. *Asteracantha longifolia* Nees. ..		×	×	×	×	×	×	×				×
9. *Azolla pinnata* R. Br.	×		×		×	×	×	×	×			×
10. *Bacopa monnieri* (Linn.) Pennell ..				×								
11. *Blyxa roxburghii* Rich.	×		×	×				×				
12. *Butomopsis lanceolata* Kunth. ..	×		×									
13. *Cæsulia axillaris* Roxb.	×			×								×
14. *Canscora decurrens* Dalz.								×				
15. *Ceratophyllum demersum* Linn. ..			×	×		×	×					×
16. *Commelina benghalensis* Linn. ..	×	×	×	×	×	×	×	×				×
17. *Cyperus* sp.	×		×	×				×				×
18. *Eclipta prostrota* Linn.	×	×	×	×	×	×	×	×	×	×	×	×
19. *Eichhornia crassipes* Solms.		×	×			×	×		×	×	×	
20. *Eriocaulon truncatum* Buch-Ham. ..	×		×					×				
21. *Hydrilla verticillata* (Linn. f.) Presl. ..	×		×	×								×
22. *Hydrolea zeylanica* Vahl.				×								
23. *Hygrophila polysperma* T. Anders. ..	×		×	×				×				×
24. *Hygrorhiza aristata* Nees.	×		×					×				

25. *Ipomæa aquatica* Forsk.		×	×	×	×	×	×	×				×
26. *Isætes coromandelina* Linn.	×											
27. *Jussiæa repens* Linn.			×	×	×	×						×
28. *J. suffruticosa* Linn.				×								×
29. *Lagarosiphon roxburghii* Benth. ..	×			×								
30. *Lemna minor* Linn.		×			×				×			×
31. *Limnathemum cristatum* Griseb. ..	×		×	×		×						×
32. *L. indicum* Thwaites	×		×									×
33. *Limnophila heterophylla* Woodr. ..	×		×	×	×							×
34. *Limnophyton obtusifolium* Miq. ..	×	×	×	×	×	×	×	×				
35. *Lindernia ciliata* (Colsm.) Pennell ..				×								×
36. *Lindernia crustacea* (Linn.) F. Muell. ..				×								×
37. *Lobelia alsinoides* Lam.		×										×
38. *Malachra capitata* Linn.								×				
39. *Marsilia quadrifolia* Linn. ..	×		×	×	×	×	×	×				×
40. *M. minuta* Linn.	×		×	×								×
41. *Melochia corchorifolia* Linn. ..	×		×	×								
42. *Monochoria vaginalis* (Burm. f.) Presl.				×				×				×
43. *Naias graminea* Del.			×	×		×						
44. *N. minor* Allioni	×	×	×	×			×	×		×		
45. *Neptunia oleracea* Lour.		×	×	×								
46. *Nymphæa rubra* Roxb.	×		×	×				×				
47. *N. stellata* Willd.	×	×	×	×	×		×	×		×		×
48. *Ottelia alismoides* (Linn.) Pers. ..	×		×	×				×				
49. *Pistia stratiotes* Linn.		×				×	×		×			×
50. *Polygonum tomentosum* Willd. ..			×	×								
51. *Potamogeton crispus* Linn.			×									
52. *P. indicus* Roxb.			×	×				×				
53. *Rumex dentatus* Linn.												×
54. *Sagittaria guayanensis* H. B. and K. ..				×								
55. *Scirpus* sp.	×		×	×				×				
56. *Sesbania aculeata* Poir. ..				×								×
57. *Sphæranthus indicus* Linn.	×			×	×	×		×	×			×
58. *Spirodela polyrhiza* Schleid.		×	×	×		×	×		×			×
59. *Trapa bispinosa* Roxb.		×	×	×		×	×	×	×	×	×	×
60. *Utricularia flexuosa* Vahl.	×		×			×	×	×				
61. *U. stellaris* Linn.	×			×				×				
62. *Vallisneria spiralis* Linn.	×											
63. *Veronica anagallis* Linn.												×
64. *Xanthium strumarium* Linn.							×					×

life-cycle in water, either completely submerged or emerged". He includes some borderline species of bogs and marshes among the aquatic plants. It is, however, difficult to draw a line between such " borderline species " and the " terrestrial plants on the shore of a lake, pond or stream which are periodically inundated or immersed and thus grow in water for a brief period " and which, according to Muenscher, are not aquatic.

The very nature of the above two definitions, which have been quoted to illustrate attempts at defining the hydrophytes, indicates that their morphology and ecological relations prove very often inadequate.

It is the extreme plasticity, so characteristic of the group as a whole, which defeats all attempts at giving a precise and comprehensive definition for the hydrophytes. Saxton (1922) while elaborating his concept of "mixed formations in time" has discussed at length this adaptability of the hydrophytes, which is particularly pronounced under monsoon conditions where the same species is capable of existing under different sets of environmental factors during its life-time.

The author has given above an ecological classification of the hydrophytes of Umred. It is based on their contacts with soil, water and air. It must be confessed, however, that even this division of the hydrophytes into various categories is, to some extent, arbitrary. For, floating hydrophytes like *Eichhornia crassipes* Solms. may also grow as emergent forms. It is also difficult to allot a category to species that grow on the edge of water, as marsh plants, sending, at the same time, extensive floating shoots that thrive happily on the surface of water, forming huge, dense mats, *e.g.*, *Ipomæa aquatica* Forsk., *Jussiæa repens* Linn., *Neptunia oleracea* Lour. and *Hygrorhiza aristata* Nees. Further, some of the anchored submerged hydrophytes like *Hydrilla verticillata* Presl. and *Naias* species may also grow suspended in water. *Hygrophila polysperma* T. Anders., which has been classified above as an emergent amphibious hydrophyte, is also capable of growing submerged in pools and puddles.

In view of these considerations, the author wishes to indicate here the desirability of finding out some characteristic feature of the vascular hydrophytes, which may be more universal and constant for the group, and, which, on account of these attributes, would not only provide a comprehensive basis for the definition, delimitation and grading of the hydrophytes, but also serve as a ready means for the fieldworker to make his collection of hydrophytes.

Summary

The paper gives an account of the floristic composition and detailed distribution of the vascular hydrophytes of Umred which is situated at a distance of about twenty-nine miles to the south-east of Nagpur. The habitats of these hydrophytes comprise some perennial lakes, ponds and a number of temporary puddles and ditches. Water level, the period for which the low-lying areas hold water and the edaphic conditions seem to control the distribution of the aquatic and marsh plants

of this region. Besides the species of *Isœtes*, *Marsilea* and *Azolla*, sixty species of angiosperms have been reported. Both primitive as well as advanced families of dicotyledons and monocotyledons are represented in this flora. Several species of hydrophytes met with in the vicinity of Nagpur are characteristically absent here.

Ecological classification of the hydrophytes based on their contacts with soil, water and air is given. It has been pointed out how the morphology and ecological relations of the hydrophytes very often prove inadequate to define them precisely. The desirability of finding out some more universal and constant characteristic feature of the group is suggested.

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GENUS *GNETUM* LINN. IN INDIA, PAKISTAN AND BURMA

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Introduction

In 1890 Hooker published in the fifth volume of his *Flora of British India*, the first consolidated account of the genus as represented in the Indo-Burman region. Prior to this, literature on the genus was represented by a few stray references to the species by Rheede (1688), Roxburgh (1874), Brandis (1874) and Kurz (1877), etc. Most of the species known to these workers were imperfectly described and their identity was ambiguous. Even Hooker was not sure about the correct definition and nomenclature of certain species.

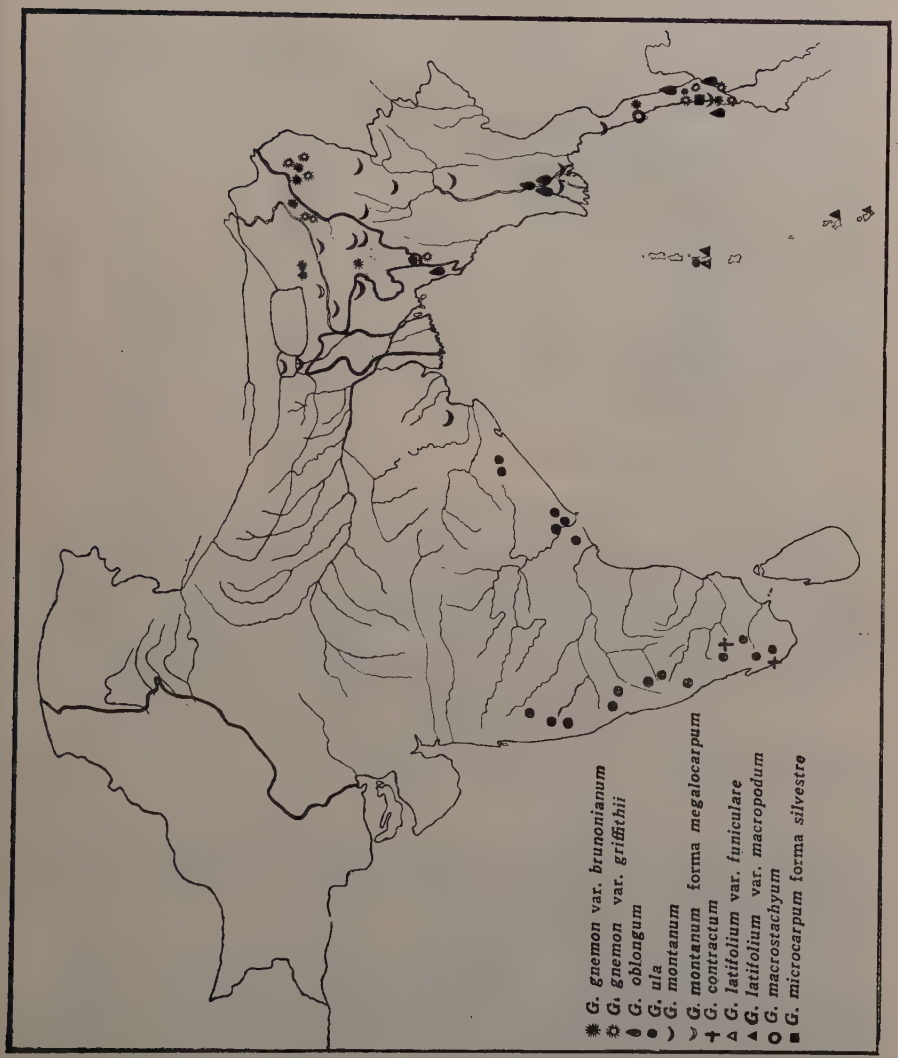
With the publication of some modern works, the genus has undergone much changes as regards definition, conception and nomenclature of its several species. Most of these changes are due to recent investigations by Markgraf (1929), whose researches have modified much of our knowledge regarding the taxonomy of the genus. Considering these facts it was thought worthwhile to publish an account of Indo-Burman species in the light of Markgraf's findings. Moreover, several new localities have been discovered for different species within the last twenty-seven years.

Eight species along with their varieties and forms have been described, giving their keys (both for male and female plants), relevant references, descriptions, localities and distribution. The material examined is lodged in the herbaria of Dehra Dun and Calcutta. No effort has been made to cite all the specimens unless the author is sure of their identification. In accordance with the more recent views of Markgraf, modern nomenclature has been adopted and where changes have occurred, the synonym as it appears in Hooker's *Flora of British India*, Vol. 5, and other Indian works is given.

Distribution

The following table shows that the genus *Gnetum* is confined to the tropical, monsoon and equatorial regions of the world, namely Equatorial South America, Trop. West Africa, India, East Pakistan, Burma, Andamans and Nicobar, Malaya Peninsula, Indonesia, Philippines, New Guinea, Siam, Indo-China and China. It is absent from Central America, Ceylon and Australia. Some of the Asiatic species show

* At present on the staff of the National Botanic Gardens, Lucknow.



Map of India, Pakistan and Burma, showing the distribution of *Gnetum* species.

a wide and discontinuous distribution and reach as far as Solomon Islands. Of these countries Malaya, Borneo and the Indo-Burman region have the highest number of species, while large continents like Africa and South America are comparatively poor.

No.	Region	No. of species	No. of endemics
1	Equatorial S. America ..	6	6
2	Trop. West Africa	2	2
3	Indo-Burman region	8	3
4	Malaya	10	1
5	Java	4	0
6	Sumatra	6	2
7	Borneo	9	4
8	Celebes	4	0
9	Philippines	4	1
10	New Guinea	5	1
11	Moluccas	3	0
12	Siam	6	0
13	China and Hainan	1	0
14	Indo-China	1	0

Most of the species are endemic within the areas of their distribution, while a few show wider distribution. The largest number of endemics are found in the South American region, but the highest number of indigenous species are found in Malaya and Borneo. It is interesting to note that none of the Asiatic species reach either Africa or America and thus form a distinct centre of *Gnetum* distribution.

Like *Ischæmum* Linn. (Bharadwaja, 1956) *Gnetum* also affords an example of the massing of endemics in certain areas and a few of wide distribution.

From the map it is evident that in the Indo-Burman region the genus is confined to the Western Ghats, Malabar Coast, Nilgiri and Pulni Hills, Godavari District of Andhra Pradesh, Orissa, Sikkim, hilly tracts of Assam, East Pakistan, Andaman and Nicobar Islands and Burma. In Burma most of the species are distributed from north to south, reaching as far as Tenasserim. Except *Gnetum ula* Brongn. and *Gnetum contractum* Mgf. all the Indo-Burman species are distributed over Assam and Burma. It is interesting to note that in Sikkim both *Ephedra* and *Gnetum* are found. The former is represented by *Ephedra saxatilis* Royle var. *sikkimensis* (Stapf) Florin (1933) and the latter by *Gnetum montanum* Mgf. This may be regarded as unusual because these genera are said to be phytogeographically unrelated.

Gnetum *Linn. Mant.* **1**: 125. 1767; *Hooker* f. *Fl. Brit. Ind.* **5**: 641. 1890; Markgraf in Engler-Prantl, *Die Nat. Pflanzenfam.* 2.

Aufl. **13**: 440. 1926 & *Bull. Jard. Bot. Buitenz. Ser.* 3. **10**: 407–511, 1929.

Evergreen, erect or climbing shrubs, rarely small trees; branches with swollen nodes. *Leaves*: petiolate, simple, entire, exstipulate opposite, decussate with distinct or indistinct reticulate venation.

Inflorescence.—A spike or a panicle of spikes, axillary, or terminal, sometimes cauliflorous; axis stout, bearing distant or approximate cupular bracts each subtending one or more rings of flowers, terminal segment usually with a whorl of sterile female flowers. *Flowers*: usually diœcious, rarely monœcious surrounded at the base with numerous jointed hairs. *Male flowers*: perianth tubular-clavate, entire or valvate, bifid; microsporophyll one, adnate to the base of the perianth and exserted from its mouth; microsporangia 2, dehiscing transversely. *Female flowers*: sessile or subsessile; perianth more or less tubular and thick; ovule ovoid or globose; integuments two in fertile flowers, one in imperfect flowers, outer integument thinner, thicker at the top and surrounding the micropylar tube, absent in the imperfect flowers, inner integument produced into a slender exserted micropylar tube with a fimbriate or toothed mouth. "*Fruit*" drupaceous, sessile or peduncled; "epicarp" fleshy or fibrous; "mesocarp" hard; "endocarp" chartaceous.

Type *Gnetum gnemon* Linn.

Species 29 with several varieties, occurring in the Tropical, Monsoon and Equatorial forests of the World.

Note.—The genus is divided (Markgraf, 1929) into two sections and five subsections of which the sections *Cylindrostachys* is the largest and most of the species of this area belong to this section.

Key to the Sections

1. Male spike with long internodes, so that the axis is visible between the bracts (except in *G. gnemon* Linn. var. *griffithii* Mgf.) .. .. .. 1. *Gnemonomorphi.*

1′. Male spike more or less cylindrical, internodes short, contracted, so that the axis is not visible between the bracts .. 2. *Cylindrostachys.*

Section 1. *Gnemonomorphi*

This section contains 10 species and 8 varieties, occurring in Asia, Africa and America. The section is further classified into three subsections, *viz.*, 1. *Eugnemones*, 2. *Micrognemones* and 3. *Aræognemones*, of which the first is represented within the Indo-Burman region. *Gnetum gnemon* Linn. is the only species of the subsection *Eugnemones*, occurring within the area.

1. *Gnetum gnemon Linn. Mant.* **1**: 125. 1767; Wall. Cat. No. 8025 B 8026 1829; Roxb., *Fl. Ind.* 518, 1832; Kurz, *For. Fl. Brit. Burma* **2**: 497. 1877; Hooker f. *Fl. Brit. Ind.*, **5**: 641. 1890;

Brandis, *Ind. Trees* 687. 1907; Markgraf in *Bull. Jard. Bot. Butienz.* Ser. 3, **10**: 436. 1929.

Trees or erect shrubs, rarely scandent. *Leaves*: variable, (on the same plant they may be elliptic and 7×3 cm. in size or oblong and 19×5 cm. in size) yellowish-green or brown in dried specimens, coriaceous; lamina oblong or elliptic, shining above, up to 20 cm. long and 9 cm. broad, acuminate; base narrow; veins distinct on the lower surface, curved and joined before the margins; petiole up to 1 cm. long.

Male inflorescence.—Simple or sometimes branched, axillary, usually solitary; bracts distant or approximate. *Male flowers*: clavate many; perianth 1·5 mm. long; sporophyll 3 mm. long; sporangia 2, globose, yellow; *imperfect female flowers* 10–15, uniseriate, globose, 2–2·5 mm. thick, apiculate or rostrate; perianth fleshy, integument thick and fleshy. *Female inflorescence*: similar to the male. *Female flowers*: 5–8 in each node, globose or obpyriform; perianth fleshy, 3–4 mm. long, 2 mm. broad; outer integument chartaceous; inner integument thick, oblong, produced into a tube, 2 mm. long, exserted outside. "*Fruit*": 1–2·5 cm. long, red, sessile, rarely stalked, ellipsoid, obtuse, apiculate, velutinous, papillose or smooth; "epicarp" fleshy, non-fibrous; "mesocarp" hard; "endocarp" chartaceous; seed oblong.

A species of 6 varieties, chiefly in Borneo, Celebes, Philippines, New Guinea, Malaya and Sunda Islands; only two within our area.

KEY TO THE VARIETIES

1. Inflorescence long, lax, rarely branched; "fruit" oblong .. .. .. var. *brunonianum*.

1′. Inflorescence short, contracted, branched; "fruit" almost rounded .. .. var. *griffithii*.

var. *brunonianum* (Griff.) Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 440. 1929; *G. brunonianum* Griff. *Notulæ* **4**: 30. 1854.

A slender shrub. *Inflorescence*: Usually simple, elongate, lax (the infl. axis visible at least between the lowest bracts). *Imperfect female flowers*: globose, obtuse, shortly apiculate. "*Fruit*": velutinose, punctate, 1 cm. long, fruiting axis thick.

Locality.—ASSAM. South Lushai Hills 1–1,500 m. *Gage* no. 269 (Herb. Dehra.); Naga Hills, Golaghat, *King* (Herb. Calc.).

BURMA: Katschin (Kachins) Hills, *Shaik Mokim* (Herb. Calc.); Mergui, *Parker* no. 2489; Tavoy distt. *BaPe* no. 41166; Tenasserim, *Proudlock* no. 65 (all Herb. Dehra.).

Distribution.—Malaya, Anamba Islands and West Borneo.

var. *griffithii* (Parl.) Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 442. 1929; *G. griffithii* Parl. in DC. *Prodr.* 16. **2**: 349. 1868.

A shrub up to 2 m. high. *Leaves*: oblong, usually with parallel margins. *Inflorescence*: usually short, often branched, always contracted (that is the infl. axis hardly visible between the bracts). *Imperfect and perfect flowers*: gradually narrowed to an acute beak. "*Fruit*": subglobose, shortly apiculate, velutinous, punctate.

Locality.—Assam. Sibsagar, *U. N. Kanjilall*, no. 3833 (Herb. Calc.); Naga Hills, Kungba, 1,500 m. *Meebold* no. 7425 (*vide* Markgraf).

Burma: Tavoy, Tenasserim river, *Parker* (Herb. Dehra.); South Tenasserim, Nagawun Chaung forest, *Parkinson* (Herb. Dehra.); Mergui, *Meebold* no. 14302 (Herb. Calc.).

Distribution.—Malaya.

Section 2. *Cylindrostachys*

Comparatively larger section having 17 species and 5 varieties occurring in India, Malaya, Indo-China, East Indies and New Guinea. It is further divided into two subsections, namely *Stipitati* and *Sessiles*, both of them are represented within the area.

Key to the Subsections

1. "Fruits" with a distinct stalk .. 1. *Stipitati.*
1′. "Fruits" sessile .. .. .. 2. *Sessiles.*

1. *Stipitati*

Bracts of the male spikes flat, with margins recurved outwards, so as to expose the flowers (except *G. contractum* Mgf. and *G. latifolium* Bl., var. *macropodum* Mgf.). "Fruits" stalked; stalk equal, longer or sometimes shorter than the "fruit".

Species 7 and varieties 6; 5 species within the area.

Key to the Species

(Male Plants)

1. Bracts of the male spikes flat, with margins recurved outwards so as to expose the flowers:—
   2. Male inflorescence usually simple:—
      3. Leaves brown on drying; lateral veins distinctly joined, tertiary distinctly and faintly reticulate on the lower surface; lamina 18 cm. long and 8 cm. broad .. .. 2. *G. oblongum.*
      3′. Leaves black on drying; lateral veins indistinctly joined before the margins, tertiary reticulate, thin, distinct on the lower surface; lamina 8–15 cm. long and 4–7·5 cm. broad .. .. .. 3. *G. ula.*

2′. Male inflorescence usually branched .. 4. *G. montanum.*

1′. Bracts of the male spike cylindrical, margins not recurved outwards, flowers included:—

4. Fertile parts of the male spike upto 1·5 cm. long and 0·4 cm. thick; inflorescence short; lamina 10 cm. long and 5 cm. broad .. .. 5. *G. contractum.*

4′. Fertile parts of the male spike up to 4 cm. thick; inflorescence lax up to 12 cm. long .. .. .. 6. *G. latifolium.*

(Female Plants)

1. Female inflorescence simple:—

2. "Fruit" smooth on drying, not pruinose, 3 cm. × 1·2–1·5 cm. .. 2. *G. oblongum.*

2′. "Fruit" longitudinally rugose on drying pruinose, 3–4 cm. × 1·5–2 cm. .. 3. *G. ula.*

1′. Female inflorescence branched:—

3. "Fruit" longer than its stalks:—

4. Leaves 30 cm. × 12 cm.; inflorescence branched twice or thrice; "fruit" ellipsoid .. .. 4. *G. montanum.*

4′. Leaves 10 cm. × 5 cm.; inflorescence branched only once; "fruit" oblong-ovate acuminate .. 5. *G. contractum.*

3′. "Fruit" shorter than its stalk .. 6. *G. latifolium.*

2. *Gnetum oblongum* Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 471. 1929; *G. funiculare* Kurz. *For. Fl. Brit. Burma* **2**: 496. 1877; Hooker f. *Fl. Brit. Ind.* **5**: 643. 1890 (non Blume).

A scandent shrub. Branches slender. *Leaves*: coriaceous, brown on drying lamina, oblong-elliptic, cuspidate or apiculate, upto 18 cm. long and 8 cm. broad; secondary veins distant curved from the origin, distinctly joined, tertiary distinctly and finely reticulate beneath; petiole thick, grooved, 2 cm. long.

Male inflorescence.—Simple, spikes 3 cm. long, 4 mm. broad; flowering bracts patelliform, 1 mm. apart from each other, margins hardly 1 mm. high. *Male flowers*: many, perianth, narrowly obconic, 1·5 mm. long, ·5 mm. broad; sporophyll 3 mm. long; sporangia 2, oblong, 0·5 mm. long; *imperfect female flowers* few, conical, 1 mm. long, 0·5 mm. broad; perianth fleshy; integument chartaceous. *Female inflorescence*: simple, up to 8 cm. long; bracts patelliform, 2 mm. high, 4 mm. broad. *Female flowers*: up to 6 in each node, oblong, surrounded by dense rusty hairs; perianth 3 mm. long, 1·5 mm. broad;

outer integument chartaceous; inner integument produced into a tube, 1 mm. exserted "*Fruit*" oblong, obtuse, apiculate, glabrous, orange-red, 3 cm. long and 1·2–1·5 cm. broad, suddenly stipitate; stalk slender, 0·8 cm. long; "epicarp" fleshy and fibrous; "mesocarp" thin, woody; "endocarp" chartaceous; seed oblong, 2 cm. long.

Locality: EAST PAKISTAN. Chittagong, Demagiri, *Lister* no. 236 (Herb. Calc.).

BURMA: Tonkyeghat, *Kurz* no. 494 (Herb. Calc.); Tavoy, Wazum Chaung, *Parker* no. 2301 (*vide* Markgraf). Mergui, Lemji, *Parker* no. 2669 (*vide* Markgraf).

Distribution.—So far endemic within the Indo-Burman region.

Markgraf (1930) remarks under this species "Very probably this is the species called *G. scandens* by Roxburgh, for his *G. scandens* came from Chittagong, where apparently only this species occurs, and where it is frequent. But this is not certain, because no original specimen can be traced, and Roxburgh's description has a printing error at the most important place where he speaks of the fruits (one line is left out and a wrong line repeated). But since he knew only one liana-type *Gnetum* he erroneously included *Ula* Rheede and *Gnemon funiculare* Rumph. Since then the various plants have been called *G. scandens* Roxb. Therefore I introduce a new name for the species of Chittagong, to be on the safe side."

In characters it resembles *G. latifolium* var. *funiculare*.

3. *Gnetum ula* Brongn. in Dup. *Voy. sur. la Coq.* 12. 1829; (non Karsten); Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 469. 1929; Fischer in *Fl. Mad.*, **3**: 1885. 1934; *G. scandens* Brandis, *For. Fl. N.W.* and *Cent. Ind.*, 502. 1874; Cooke, *Fl. Presid. Bombay*, **2**: 665. 1907; *Ula* Rheede, *Hort. Malab.* **7**: 41, t. 22. 1688.

An extensive woody climber. Branches with swollen nodes, lenticellatus. *Leaves*: black in dried specimens; lamina ovate-elliptic, shortly acuminate, 8–15 cm. long and 4–7·5 cm. broad; base round or contracted into a petiole; veins 5–6 on either side of the midrib, curved, indistinctly joined before the margins, tertiary reticulate, thin, distinct on the lower surface.

Male inflorescence.—Simple or branched; peduncle 2 cm. long, with two lanceolate scales at the middle, fertile parts narrow, 2–2·5 cm. long and 4 mm. thick; flowering bracts acetabuliform, much approximate if not appressed, up to 1 mm. high. *Male flowers*: many, broadly-clavate; perianth 1·4 mm. long, thin at the base, up to 0·5 mm. broadly dialated; sporophyll filiform; sporangia 2, yellow, ellipsoid, arising 1 mm. above the perianth; *imperfect female flowers* up to 20, narrowly ovate, 0·5 mm. high, integument included. *Female inflorescence*: simple cauliflorus, up to 8 cm. long or more, lowest internode elongated; bracts acetabuliform, 5 mm. in diam., 4 mm. apart, basal scale lanceolate,

distinct. *Female flowers*: 5–6 in each node, sessile, globose, 3 mm. thick, tube of the outer integument about 1 mm. exserted with a cleft apex; perianth fleshy. "*Fruit*" oblong, obtuse or shorthly apiculate, pruinose, always longitudinally rugose on drying, 3–4 cm. long and 1·5–2 cm. broad, stalk 0·3–1 cm. long; "epicarp" fleshy, 2 mm. thick, fibrose; "mesocarp" thin, woody; "endocarp" chartaceous; seed oblong, 2 cm. long.

Locality: BOMBAY. Yellapur, *Bor* (Herb. Dehra.); Khandala Valley, *Braganza* (Herb. Dehra.); Kanara, *Hohenacker* no. 2339 (*vide* Markgraf) Poona, *Woodrow* no. 16 (Herb. Calc.).

MYSORE: "Evergreen forests Coorg" *Jain* and *Bharadwaja* (Herb. Dehra.): Agalhatti, *Meebold* no. 8484 (*vide* Markgraf).

KERALA: Nilambar, *Vaid* (Herb. Dehra.); Quilon, *Wight* no. 2757 (*vide* Markgraf).

MADRAS: Nilgiris, Chenath Nair Hills, *Fischer* no. 2595 (Herb. Calc.); Pulni Hills (*vide* Markgraf).

ANDHRA: Godavari District (*vide* Markgraf).

ORISSA: Ganjam, Mahendragiri, 1,300 m. *Fischer* and *Gage* (Herb. Calc.).

ANDAMANS: South Andaman, *Kirat Ram* (Herb. Dehra.).

Distribution.—So far endemic within the area.

4. *Gnetum montanum*. Markgraf in *Bull. Jard. Bot. Buitenz*. Ser. 3. **10**: 466. 1929; *G. scandens* (aut. plur.) Hooker f. *Fl. Brit. Ind.* **5**: 642. 1890; *G. edule* Kurz. *For. Fl. Brit. Burma* **2**: 495. 1877 (non Blume).

A robust climber. Branches smooth, slender, swollen at the nodes. *Leaves*: dark green, black in dried specimens; lamina ovate, sometimes oblong-ovate, acuminate, up to 30 cm. long and 12 cm. broad (sometimes smaller); base rounded; secondary veins distant, curved towards the margins, indistinctly joined, tertiary indistinctly reticulate; petiole, 1–1·5 cm. long.

Male inflorescence.—Branched twice; branches aggregate at the nodes, upto 8 cm. long; peduncle short, hardly exceeding 1 cm., fertile parts of the spikes 3 cm. long; flowering bracts patelliform, 1 mm. high, 4 mm. broad, densely approximate. *Male flowers*: up to 20; perianth 1 mm. long, shortly obconic; sporophyll hardly 1 mm. exserted; sporangia 2, small, globose; *imperfect female flowers* ovoid, 1 mm. high, perianth and integuments equal, chartaceous, integument with a shortly cleft apex. *Female inflorescence*: branched twice or thrice; bracts hardly 5 mm. distant from each other, acetabuliform, 4 mm. broad, 1 mm. high. *Female flowers*: 5–7 in each bract, ovate; perianth 3 mm. long, 2 mm. thick, fleshy; outer integument 2 mm. long, chartaceous; inner integument chartaceous, produced into a slender projecting tube, with toothed mouth. "*Fruit*": ellipsoid, 1·5 cm. long, 1 cm. broad, rarely more (f. *megalocarpum*), shining, smooth, shortly

stalked; "epicarp" red, fleshy, thin, fibrous; "mesocarp" thin, woody; "endocarp" chartaceous; seeds oblong.

Locality: ASSAM. Silhet, *King*, 1882 (Herb. Dehra.); Nahrabbi, without collecter (Herb. Dehra.); "Assam" without exact locality, *Jenkins* (Herb. Dehra).

SIKKIM: Darjeeling, *Gamble* no. 9814; "Sikkim" 1·500 m. without exact locality, *King* no. 977 (both Herb. Dehra.).

ORISSA: Mayurbhanj, without collecter, no. 769 (Herb. Dehra.).

BURMA: Katha Distt. 333 m. *Rogers*; Pegu, *Kurz*; Tharawaddy, *Rogers* (all Herb. Dehra.); Martban, *Kurz* no. 2220 (Herb. Calc.).

Distribution.—Siam, China and Indo-China.

Forma *megalocarpum* Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 458, 1929.

Leaves large. "Fruit" 3 cm. long, 1·8 cm. broad, stalk 8 mm. long.

Locality.—ASSAM. Daphla (Dafla) Hills, *Lister* (Herb. Calc.).

Distribution.—So far endemic in Assam.

5. *Gnetum contractum* Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 470. 1929; Fischer in *Fl. Mad.* **3**: 1885. 1934; *G. scandens* Hooker f. *Fl. Brit. Ind.*, **5**: 642, 1890, non Roxb. (in part).

A scandent shrub. Branches terete, rarely lenticellatus. *Leaves*: subcoriaceous, black in dried specimens; lamina elliptical or ovate, shortly acuminate, up to 10 cm. long, 5 cm. broad; base ± rounded; veins distinct, thin; secondary curved, indistinctly joined before the margins; petiole 1 cm. long.

Male inflorescence.—Short, branched only once, fertile parts usually sessile, up to 1·5 cm. long, 4 mm. thick; bracts cylindrical dense, 2 mm. high. *Male flowers* (young): many, broadly obconic, 1 mm. long; sporophyll with 2 sporangia; *imperfect female flowers* up to 10, oblique, oblong, apiculate, much smaller than male; integument deeply cleft. "*Fruit*" oblong-ovate, long acuminate, 3–3·5 cm. long, 1·5 cm. thick, smooth, stalk 3–6 mm. long, 2 mm. thick; "epicarp" 1 mm. thick, fibrous; "mesocarp" thin, woody; "endocarp" chartaceous, shining; seed oblong, 2·5 cm. long.

Not easily distinguished from *G. ula* Brongn. in vegetative condition.

Locality.—KERALA. Quilon, *Wight* no. 2755 (*vide* Markgraf).

MADRAS. Nilgiri Hills, Coonoor, *Perrottet* no. 508 (*vide* Markgraf).

Distribution.—So far endemic.

6. *Gnetum latifolium* Blume in *Tij. Nat. Ges.* **1**: 160. 1834; Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3, **10**: 458. 1929.

A scandent shrub, rarely lenticellatus. *Leaves*: dark-green, usually black, rarely brown in dried specimens, more or less coriaceous;

lamina elliptic, shortly acuminate, mostly broadly-ovate, often large, up to 25 cm. long and 12 cm. broad; lowest 2 or 3 veins approximate, others distant, curved towards the margins, distinct on the lower surface or indistinct; petiole thick, 1 cm. long, usually grooved.

Male inflorescence: lax, branched only once, terminal, much branched if cauliflorous, up to 12 cm. long, fertile parts of the spikes up to 4 cm. long, 4 cm. broad; bracts patelliform, rarely cylindrical (in var. *macropodum*) 1·5 mm. high, 2·5 mm. distant from each other. *Male flowers*: many, broadly obconic, 1·5 mm. long, 1 mm. broad; sporophyll 3 mm. long, thin; sporangia 2, narrowly oblong, 0·5 mm. long; *imperfect female flowers* few, 6–8, broadly conical, 1 mm. long, 0·5 mm. broad; integument cleft at the apex. *Female inflorescence*: once or twice branched, up to 15 cm. long; bracts acetabuliform, 4 mm. in diam., 3 mm. apart from each other. *Female flowers*: 6–9 in each 4 mm. long, 1·5 mm. thick, apex long, acuminate, furrowed, curved node, above; perianth 0·5 mm. thick, fleshy; outer integument 2 mm. high, chartaceous, shortly apiculate; inner integument 4 mm. long, cleft to 0·5 mm. "*Fruit*" red, broad or narrowly ellipsoid, 2–2·5 cm. long, 1–1. cm. thick; stalk 0·5–2 cm. long; "epicarp" fleshy and fibrous, more or less shining; "mesocarp" thin, hard; "endocarp" chartaceous.

KEY TO THE VARIETIES

1. Leaves black in dried specimens; veins indistinctly reticulate, joined near the margins .. .. var. *macropodum*.

1′. Leaves brown in dried specimens; veins distinctly forming a coarse reticulum on the lower surface .. .. var. *funiculare*.

var. *macropodum* (Kurz) Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 462. 1929; *G. macropodum* Kurz in *Journ. Bot.* **13**: 331. 1875; Hooker f. *Fl. Brit. Ind.* **5**: 643. 1890.

Leaves: large, base more or less cordate. *Inflorescence*: cauliflorous, up to 30 cm. long; male spikes with cylindrical bracts. "*Fruit*": stalked; stalk equal or longer than the "fruit".

Locality: ANDAMANS. Port Blair, *King* (Herb. Kew, *vide* Markgraf); Mount Harriet, *Kurz* (Herb. Calc.); South Andamans, *Parkinson* no. 1067 (Herb. Dehra.).

NICOBAR. Kamorta, *Kurz* (Herb. Kew, *vide* Markgraf).

Distribution.—As above.

var. *funiculare* (Bl.) Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 463. 1929; *G. funiculare* Bl. *Tij. Nat. Ges.* **1**: 162. 1834.

Characters as in Key.

Locality.—SOUTH ANDAMANS. Port Monat, *King* (Herb. Calc.).

Distribution.—Malaya, Siam, Sumatra and Java.

2. *Sessiles*

Bracts of the male spike cylindrical, with margins not recurved outwards, flowers included (see also *G. contractum* Mgf. and *G. lattifolium* Bl.).

Species 11, varieties and forms 4; species only 2 within our area.

KEY TO THE SPECIES

(Male Plants)

1. Male spikes 5 cm. × 0·7 cm.; lamina coriaceous, brown in dried specimens, 18 cm. × 8 cm. .. .. .. 7. *G. macrostachyum.*

1′. Male spike 1·5 cm. × ·35 cm.; lamina fleshy, green, 13 cm. × 5 cm. .. 8. *G. microcarpum.*

(Female Plants)

1. Female inflorescence 9 cm. × 1 cm.; fruiting axis up to 10 cm. long; lamina coriaceous, 18 cm. × 8 cm., elliptic .. .. 7. *G. macrostachyum.*

1′. Female inflorescence 3 cm. × ·5 cm.; fruiting axis up to 6 cm.; lamina fleshy, 13 cm. × 5 cm. oblong-elliptic or lanceolate .. .. .. 8. *G. microcarpum.*

7. *Gnetum macrostachyum* Hooker f. *Fl. Brit. Ind.* **5**: 642. 1890; Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 484. 1929.

A stout woody climber. Branches lenticellose. *Leaves*: coriaceous; lamina elliptic, acuminate, up to 18 cm. long and 8 cm. broad, base rounded; veins distinct below, secondary curved, 6–8 on either sides, distinctly joined, tertiary reticulate; petiole 1 cm. long.

Male inflorescence: simple up to 5 cm. long, 7 mm. thick; bracts cylindric, 3 mm. high. *Male flowers*: clavate, 1·5 mm. long, intermixed with long dense hairs; sporophyll shortly exserted, sporangia 2, ellipsoid; *imperfect female flowers* about 10, oblique, ovate, fleshy; integument chartaceous, slightly exserted. *Female inflorescence*: simple, often cauliflorus, up to 9 cm. long, 1 cm. thick; bracts closely approximate, 4 mm. high, infundibuliform or nearly cylindric. *Female flowers*: 8–10, globose, apiculate, surrounded by profuse hairs; perianth fleshy; outer integument chartaceous, shortly rostrate, smaller than perianth; inner integument prolonged into a tube, exserted upto 1·5 mm. "*Fruit*" sessile, shining, ellipsoid, shortly mucronate, 2 cm. long and 1·2 cm. broad; "epicarp" thin, fleshy and sparingly fibrous; "mesocarp" coriaceous; "endocarp" chartaceous, shining.

Locality: BURMA. Tavoy, *Parker* (Herb. Dehra.).

Distribution: Malaya, Sumartra, Java and New Guinea.

A very distinct species.

8. *Gnetum microcarpum* Blume in *Rumphia* **4**: 7, *t.* 175, Fig. 1. 1848; Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 485. 1929;

G. neglectum Kurz in *Flora* **55**: 350. 1872; *For. Fl. Brit. Burma* **2**: 946. 1877; Hooker f. *Fl. Brit. Ind.* **5**: 642. 1890.

A scandent shrub. Branches slender, terete. *Leaves*: coriaceous, fleshy, shining above, black in dried specimens; lamina oblong-ellliptic or lanceolate, acuminate; up to 13 cm. long and 5 cm. broad, mostly small; base rounded or cuneate; veins 7–9, straight, curved towards the margins, joined, indistinct; petiole 6–8 mm. long.

Male inflorescence: cauliflorus, simple, short, peduncle hardly 1 cm.; spike 1·5 cm. long and 3·5 mm. thick; bracts cylindric, 1·5 mm. high, ·5 mm. apart from each other. *Male flowers*: many (40–80), obconic, 1·5 mm. long and 5 mm. broad; sporophyll 3·5 mm. long, sporangia 2, oblong, yellow; *imperfect female flowers* many (20–30), ovate or fusiform, 1·5–2 mm. long; perianth fibrous; integument chartaceous, acuminate. *Female inflorescence*: cauliflorus, simple, dense, short; peduncle 1 cm. long; spike 2·5 cm. long, 5 mm. thick; bracts infundibuliform, 3 mm. high, 5 mm. broad, 2 mm. apart from each other. *Female flowers*: 8, 3 mm. long, 2 mm. broad, ovate-acuminate, apex slightly curved; perianth 0·5 mm. thick, fleshy, fibrous; outer integument chartaceous, 1 mm. high, rostrate; inner integument produced into a tube, tube exserted, cleft at the apex. "*Fruit*" red, smooth ellipsoid, more or less shining, acute, up to 2 cm. long and 1·2 cm. thick; "epicarp" thin, fleshy, sparingly fibrous; "mesocarp" hard, coriaceous; "endocarp" chartaceous; seed oblong, up to 1 cm. long, 0·5 cm. thick.

Forma *silvestre* Ridley in *Journ. Straits Branch, R. As. Soc.*, **60**: 62. 1911; Markgraf in *Bull. Jard. Bot. Buitenz.* Ser. 3. **10**: 486. 1929.

Leaves: oblong-elliptic with a round base.

Locality: BURMA. Mergui, *Griffith* no. 4972 (Herb. Calc.).

Distribution.—Malaya to Sumatra.

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FUNGI FROM HYDERABAD (DECCAN)—I

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1.* **Cercospora nigri** Tharp.

Tharp. B. C., *Mycologia*, **9**; 112, 1917; Saccardo, P. A., *Syll. Fung.*, **4**: 449, 1886; **10**: 635, 1892.

Habit.—On living leaves of *Solanum nigrum* L. (Solanaceæ), Secunderabad, 15–11–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 35.

2.* **Cercospora solani-melongenæ** Chupp apud Chupp and Doidge. Thompson, A. and Johnston, A., *Mycol. Pap.*, **52**: 29, 1953.

Habit.—On living leaves of *Solanum melongena* L. (Solanaceæ), University Campus, 10–10–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 36.

3.* **Cercospora acalyphæ** Peck.

Tharp, B. C., *Mycologia*, **9**: 106, 1917. Saccardo, P. A., *Syll. Fung.*, **4**: 457, 1886.

Habit.—On living leaves of *Acalypha indica* L. (Euphorbiaceæ), Secunderabad, 15–11–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 37.

4.* **Cercospora bidentis** Tharp.

Tharp, B. C., *Mycologia*, **9**: 106, 1917.

Habit.—On living leaves of *Bidens bipinnata* L. (Compositæ), University Campus, 11–1952, P. N. Rao, O. U. B. Herb. ' Hy ' No. 39.

5.* **Cercospora ludwigiæ** Atk.

Saccardo, P. A., *Syll. Fung.*, **10**: 625–26, 1892.

Habit.—On living leaves of *Ludwigia parviflora* Roxb. (Onagraceæ), Narsapur forest, 6–11–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 40.

6.* **Cercospora zinniæ** Ell. and Mart.

Ellis, J. B. and Mart., *J. Mycol.*, **1**: 20, 1885. Saccardo, P. A., *Syll. Fung.*, **4**: 443, 1886.

Habit.—On living leaves of *Zinnia* sp. (Compositæ), Narsapur forest, 10–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 41.

7. **Cercospora personata** (Berk. and Curt.) Ell. and Everh.

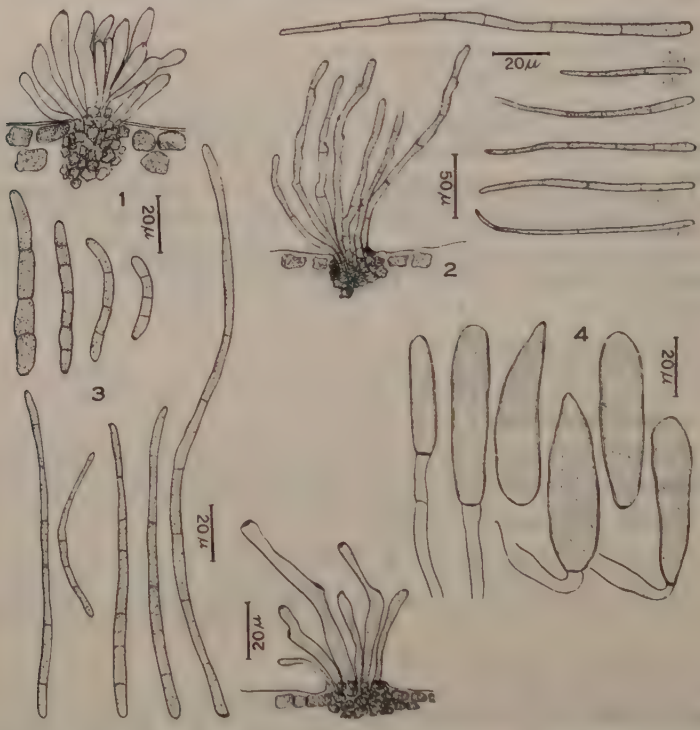
Ellis, J. B. and Everhart, B. M., *J. Mycol.*, **1**: 63, 1885.

Habit.—On living leaves of *Arachis hypogæa* Willd. (Papilionaceæ), Himayetsagar Farm and other groundnut growing areas, 10–8–1955, M. A. Salam, O. U. B. Herb. ' Hy ' No. 42.

8. **Cercospora arachidicola** Hori.

Woodroof, N. C., *Phytopath.*, **23**: 627–40, 1933.

Habit.—On living leaves of *Arachis hypogæa* Willd (Papilionaceæ), Himayetsagar Farm and in other groundnut growing areas, 10–8–1955, M. A. Salam, O. U. B. Herb. ' Hy ' No. 43.



Figs. 1–4. Fig. 1. *Cercospora lycopersici.* Fig. 2. *Cercospora dahliicola.* Fig. 3. *Cercospora lagenariae.* Fig. 4. *Ovularia hyderabadense.*

9. **Cercospora lagenariæ** sp. nov.

Infection spots epiphyllous, minute, circular to sub-circular zonate, with a glistening brown centre, encircled by a dark margin, measuring 4–10 mm. in diameter.

Conidiophores light brown, arising in convergent tufts, sub-epidermal, mostly straight, unseptate, geniculate, measuring 46·8–90·0 × 3·2–4·8 μ. Conidia hyaline, pluriseptate, curved, cylindric or upward attenuate, not guttulate, measuring 43·2–162·0–(216·0) × 3·2 μ.

Habit.—On living leaves of *Lagenaria vulgaris* Ser. (Cucurbitaceæ), Secunderabad, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 44.

The present fungus found to be distinct in its morphological characters from the hitherto known species of *Cercospora* parasitizing members of Cucurbitaceæ, hence it has been reported as a new species.

Cercospora lagenariæ spec. nov.

Infectionid maculæ epiphyllæ, minutæ, circulares vel sub-circulares, zonatæ, centro nitenti brunneo, margine circumdante fusco, magnitud, 4–10 mm. diam.

Conidiophori pallide brunnei, surgentes in fascicules convergentes, subepidermales, ut plurimum recti, nonseptati, geniculati magnit. 46·8–90·0 × 3·2–4·8 μ. Conidia hyalina, pluriseptata, curva, cylindrica vel sursum attenuata, haud guttulata, magnit 43·2–162·0 (216·0) × 3·2 μ.

Habitat in foliis ventibus *Lagenariæ vulgaris* Ser., e familia cucurbitacearum, in loco Secunderabad, die 8 mensis Septembris anni 1955; typus lectus a P. N. Rao et positus in O. U. B. Herbario ' Hy ' subnumero 44.

10. **Cercospora momordicæ** McRae.

McRae, W., *Annales crypt. Exot.*, **11**: 262–67, 1930.

Habit.—On living leaves of *Momordica charantia* L. (Cucurbitaceæ), University Campus, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 45.

11. **Cercospora pulchra** Syd.

Sydow, H., Mitter, J. H. and Tandon, R. N., Fungi Indici, iii, *Ann. mycol.*, **35**: 241, 1937.

Habit.—On living leaves of *Cratæva religiosa* Forest., (Capparidaceæ), University Campus, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 46.

12. **Cercospora ricinella** (Sacc. and Berl.) Speg.

Saccardo, P. A., *Syll. Fung.*, **22**: 1432, 1913.

Habit.—On living leaves of *Ricinus communis* L. (Euphorbiaceæ), Mannanur forest, 20–1–1956, M. A. Salam, O. U. B. Herb. ' Hy ' No. 47.

13. **Cercospora batatæ** Zimm.

Saccardo, P. A., *Syll. Fung.*, **18**: 605, 1906.

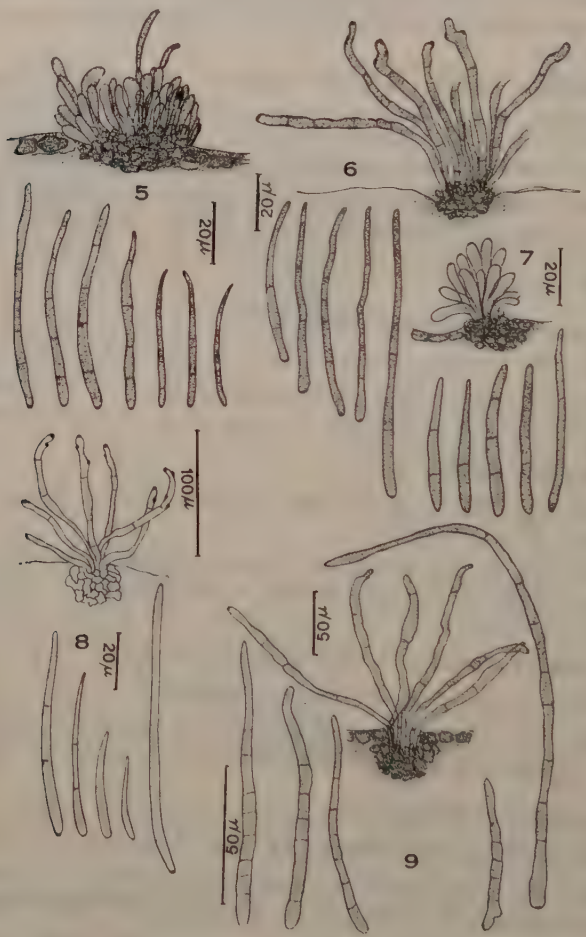
Habit.—On living leaves of *Ipomæa batata* Poir. (Convolvulaceæ), University Campus, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 48.

14. **Cercospora dahliicola** sp. nov.

Infection spots hypophyllous, oval to spherical, sometimes confluent with a white sunken centre, and a dull grey margin, measuring 3–8 mm. in diameter. Stroma minute measuring 36·0–54·0 μ in diameter. Conidiophores dark olive brown, in fascicles of 5–15, straight or bent geniculate, sub-epidermal, 4–6 septate, measuring 100·8–198·0 × 3·2–4·8 μ. Conidia sub-hyaline, needle-like, indistinctly septate, obclavate, with a tapering rounded apex, measuring 46·8–126·0–(144·0) × 2·4–4·8 μ.

Habit.—On living leaves of *Dahlia* sp. (Compositæ), Public Garden, Secunderabad, 10–10–1955, P. N. Rao, O. U. B. Herb. 'Hy' No. 49.

The fungus on the present host was found to be distinct in its conidial measurements from those of the species known to parasitize members of Compositæ.



FIGS. 5–9. Fig. 5. *Cercospora solani-melongenae*. Fig. 6. *Cercospora bidentis*. Fig. 7. *Cercospora acalyphae*. Fig. 8. *Cercospora ludwigiae*. Fig. 9. *Cercospora zinniae*.

Cercospora dahliicola spec. nov.

Infectionis maculæ hypophyllæ, ovales vel sphæriceæ, non-numquam confluentes, centro depresso albo, mangine obscurate griseo, magnit. 3–8 mm. diam. Stroma minuta, magnit. 36·0–54·0 μ diam. Conidiophori fusce olivaceo brunnei, in fasciculos aggregati 5–15, recto vel,

geniculati, subepidermales, 4–6 septati, magnit. 100·8–198·0×3·2–4·2 μ conidia subhyalina, acuiformia indistincts septata, obclavata, apice rotundato et factigato, magnit. 46·8–126·0–(144·0) × 2·4–4·8 μ.

Typus lectus in foliis viventibus Dahliæ speciei ignotæ, e familia Compositarum, in Hortibus publicis in loco Secunderabad, die 10 mensis Octobris anni 1955 a P. N. Rao et positus in O. U. B. Herbario 'Hy' numero 49.

15. **Cercospora lycopersici** sp. nov.

Infection spots minute, dark brown with a dull white centre, measuring 3–5 mm. in diameter. Stroma minute, dark and amphigenous measuring 28·8–72·0 μ in diameter. Conidiophores short, stout, dark olive brown in dense and divergent tufts, unseptate, unbranched, geniculate with older scars present showing the succession of conidia, measuring 21·6–36·0 × 4·8–6·4 μ. Conidia light brown 3–7 septate, slightly constricted obclavately fusoid, not guttulate, smooth, measuring 24·0–67·2×3·2–4·8 μ.

Habit.—On living leaves of *Lycopersicum esculentum* Mill (Solanaceæ), Osmania University Campus, 6–6–1955, P. N. Rao, O. U. B. Herb. 'Hy' No. 50.

The fungus was presented as a new species since it does not agree in its morphological characters with any of the species of *Cercospora* reported on members of Solanaceæ.

Cercospora lycopersici spec. nov.

Infectionis maculæ minute, fusce brunneæ, centro obscurate albo, magnit. 3–5 mm. diam. Stromata minuta, fusca, amphigena magnit. 28·8–72·0 μ diam. Conidiophori breves, robusti, fusce olivaceo-brunnei in densis et divergentibus fasciculis, non-septati, non-ramosi, geniculati, cicatricibus vetustioribus præsentibus atque monstrantibus successionem conidiorum magnit. 21·6–36·0 × 4·8–6·4 μ. Conidia pallide brunnea, 3–8 septata, tenuiter constricta, obclavata fusioidea, non-guttulata, levia, magnit. 24·0–67·2 × 3·2–4·8 μ.

Typus lectus in foliis viventibus *Lycopersicum esculentum* Mill e familia Solanacearum, in Campo Universitatis Osmania die 6 mensis junii anni 1955, a P. N. Rao et positus in O. U. B. Herb. 'Hy' sub-numero 50.

16. **Ovularia hyderabadense** sp. nov.

Causing cottony white patches on the lower surface of the leaves; spots become visible when leaves get dried up, irregular and brownish, measuring 2–5 mm. in diameter. Conidiophores hyaline, unbranched, unseptate mostly straight, but rarely curved, smooth, measuring 35·2–56·0 × 3·2–7·2 μ. Conidia hyaline, golden yellow in transmitted light, large, single-celled, elliptical or obclavate, with a tapering pointed apex, produced acrogenously and singly at the tip of the conidiophore, measuring 54·4–72·0 × 12·8–17·6 μ.

Habit.—On living leaves of *Euphorbia geniculata* Ort. (Euphorbiaceæ), University Campus, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 51.

Conidial measurements and morphology of the fungus are distinct to warrant it as a new species.

Ovularia hyderabadense spec. nov.

Causat maculas albidas gossypinas in feriore pagnia foliorum; maculæ distinctæ evadunt cum folia siccantur, irregares et brunneolæ, magnit. 2–5 mm. diam. Conidiophori hyalini, non-ramosi, non-septatim ut plurimum recti, raro curvati, leaves, magnit. 35·2–56·0 × 3·2–7·2 μ. Conidia hyalina, aureo-lutea sub luce transmissa, ampla, unicellulata, elliptica vel obclavata, spice acuto factigato, acrogene producta singulariter atque ad apicem conidiophororum, magnit. 54·4–72·0 × 12·8–17·6 μ.

Typus lectus in foliis viventibus *Euphorbia geniculata* Ort. e familia Euphorbiacearum, in campo Universitatis, die 8 mensis septembris, a P. N. Rao, et positus in O. U. B. Herb. ' Hy ' sub-numero 51.

17. **Plasmopara vernoniæ-chinensis** Saw.

Sawada, K., *Agri. Expt. Stn. Government of Formosa. Spec. Bull.*, **19**: 98, 1918. Campbell, L. *Mycologia*, **24**: 330–33, 1932.

Habit.—On living leaves of *Vernonia cinerea* Less. (Compositæ), Secunderabad Garden, 13–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 52.

18. **Plasmopara wildemaniana** P. Henn.

Saccardo, P. A., *Syll. Fung.*, **21**: 861, 1912.

Habit.—On living leaves of *Peristrophe bicalyculata* Nees. (Acanthaceæ), University Campus, 8–9–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 53.

19. **Colletotrichum compactum** Ramakr.

Ramakrishnan, T. S., *Proc. Indian Acad. Sci.*, **B 34**: 70, 1951.

Habit.—On pods of *Albizzia lebbeck* Benth. (Papilionaceæ), University Campus, 8–11–1955, P. N. Rao, O. U. B. Herb. ' Hy ' No. 54.

20. **Arthrobotryum coonoorense** Subramanian

Subramanian, C. V., *Proc. Indian Acad. Sci.*, **B 42**: 283–92, 1955.

Habit.—On living leaves of *Thysanolæna* sp. (Graminæ) Mannanur forest, M. A. Salam, 25–10–1954, O. U. B. Herb. ' Hy ' No. 55.

21. **Stigmina palmivora** (Sacc. apud Trelease) Hughes.

Hughes, S. J., *Mycol. Pap.*, **49**: 13, 1952. Saccardo, P. A., *Syll. Fung.*, **16**: 1106, 1906. Subramanian, C. V., *J. Indian bot. Soc.*, **35**: 81–82, 1956.

Habit.—On living leaves of *Phœnix sylvestris* Roxb. (Palmæ), Narsapur forest 12–4–1956; P. Rama Rao, O. U. B. Herb. 'Hy' No. 56.

22. **Macrophoma bœrhaaviæ** Ramakr. and Sundaram.

Ramakrishnan, T. S. and Sundaram, *Proc. Indian Acad. Sci.*, **42 B** (2): 59, 1955.

Habit.—On living leaves of *Bærhaavia diffusa* L. (Nyctaginaceæ), University Campus, 9–8–1955, P. N. Rao, O. U. B. Herb. 'Hy' No. 57.

23. **Cladosporium fulvum** Cooke in *Grevillea*, **12**: 32, 1883.

Saccardo, P. A., *Syll. Fung.*, **4**: 363, 1886.

Habit.—On living leaves of *Lycopersicum esculentum* Mill (Solanaceæ), Secunderabad, 10–10–1955, P. N. Rao, O. U. B. Herb. 'Hy' No. 58.

Summary

In this paper (which is the first of the series) 23 species of fungi collected from Narsapur forest and the vicinity of Hyderabad are described of which the species marked with asterisks, *i.e.*, *Cercospora nigri*, *C. solani-melongenae*, *C. acalyphae*, *C. bidentis*, *C. zinniae*, *C. ludwigiae* are new records to India and *Cercospora dahliicola*, *C. lagenariae*, *C. lycopersici*, *Ovularia hyderabadense* are presented as new species. Duplicate sets of herbarium of new species are deposited in the Herb. Crypt Ind. Orient of the Agricultural Research Institute, New Delhi.

Acknowledgements

The authors wish to express their sincere thanks to Prof. M. Sayeeduddin for his encouragement, and to Rev. Father H. Santapau for kindly translating the diagnoses of the new species into Latin. Thanks are also due to Prof. T. S. Sadasivan and Dr. C. V. Subramanian of the Madras University for their helpful suggestions in preparation of this paper.

THE PEZIZACEÆ OF THE MUSSOORIE HILLS–IV

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This paper is intended to record more Pezizaceæ from the Mussoorie Hills (5,000–7,000 ft. altitude in the North-Western Himalayas) as a part of the study of the Fungal Flora of that region undertaken by Dr. K. S. Thind and his students (Thind and Batra, 1956; Thind and Sethi, 1957). Of the 8 species described here 4 are new records for India, while 1 variety *Lamprospora spinulosa* Seaver var. *magnispora* var. nov. is described here as a new variety.

The numbers of the species are the serial numbers of the Pezizoid Flora.

Collections have been deposited in the Herbarium of the Panjab University. Duplicate material, in formalin-alcohol, is at the Mycological collections of the Bureau of Plant Industry, Beltsville, Maryland, U.S.A.

22. *Lamprospora spinulosa* Seaver var. *magnispora* var. nov.

Apothecia flava usque aurantiaca, 0·5–1 mm. diam., extus incarnata; ascosporæ magna, dense spinuloso, spinulis usque 4 μ longis; paraphyses aurantiaca, apice inflatæ.

Apothecia 0·5–1 mm. in diameter, gregarious, sessile, globose at first, becoming discoid at maturity, depressed in the substratum, yellow to orange, fleshy, brittle; external surface pinkish; excipular cells strongly swollen and giving rise to septate, unbranched mycelial threads which extend around the hymenium so as to form a fringe-like border; margin entire; hymenium concave to plane, orange, roughened by protruding asci.

Asci 240–280 × 24–28 μ, clavate, apex rounded, tapering below into a short stem-like base.

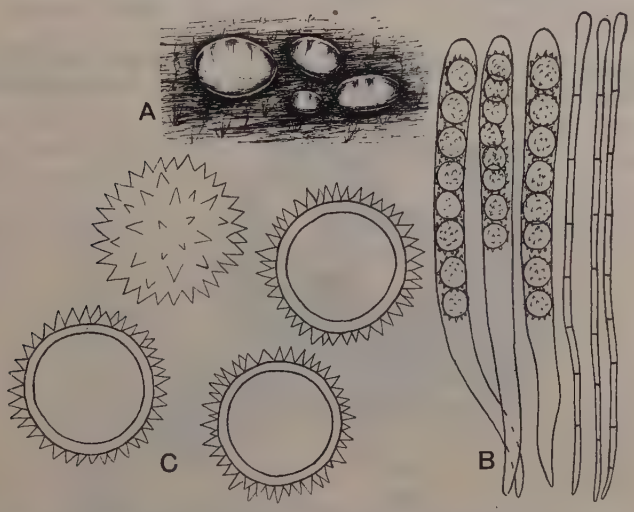
Ascospores 20–24 μ in diameter excluding the spines, 8 in number, uniseriate, hyaline to subhyaline, globose, smooth when young, prominently and profusely spinulose at maturity, spines large, stout, blunt to subacute and up to 4 μ long, uniguttulate, guttule large and filling almost whole of the spore cavity.

Paraphyses 200–300 × 2–3 μ, up to 7–8 μ wide at the top, clavate, usually simple, sometimes branched, septate, orange, considerably enlarged at the top.

Text-Fig. 1, A–C.

Collected on soil, Mussoorie, August 15, 1952, **153.**

The spores of this Mussoorie collection (n. 153) are much larger for *Lamprospora spinulosa* Seaver (1914) and hence it is regarded a new variety of this species. The name *magnispora* var. nov. is proposed because of larger spores. Spines on the spores of the Mussoorie collection are also bigger for *L. spinulosa*. All the other characters of the Mussoorie collection are within the range of *L. spinulosa*. It is scarcely different enough from the latter to be regarded as a separate species.



TEXT-FIG. 1. *Lamprospora spinulosa* Seaver var. *magnispora* var. nov. A. Apothecia, ×10. B. Asci and paraphyses, ×200. C. Prominently spinulose ascospores with one large gutta, ×950.

23. *Lamprospora carbonaria* (Fckl.) Seaver, *Mycologia*, **6**: 16, 1914.

Syn. *Crouania carbonaria* Fuckel, *Symb. Myc. Nachtr.*, **2**: 64, 1873.

Peziza sanguinaria Cooke, *Grevillea*, **3**: 31, 1874.

Barlæa carbonaria Sacc., *Syll. Fung.*, **8**: 112, 1889.

?*Lamprospora carbonicola* Boud., *Hist. Class. Discom. Eu.* 68, 1907.

Pulvinula carbonaria Boud., *Hist. Class. Discom. Eu.*, 70, 1907.

Barlæina carbonicola Sacc., and Trav.; Sacc. and Trott. in *Sacc. Syll. Fung.*, **22**: 622, 1913.

Apothecia 2–4 mm. in diameter, gregarious, often congested together, sessile, globose and shallow cupulate at first, later expanding and becoming discoid, pink, brown on drying, fleshy, brittle, often

contorted due to mutual compression; external surface smooth, lighter coloured than the hymenial surface, light pink; margin entire to wavy; hymenium concave to plane, smooth, pink.

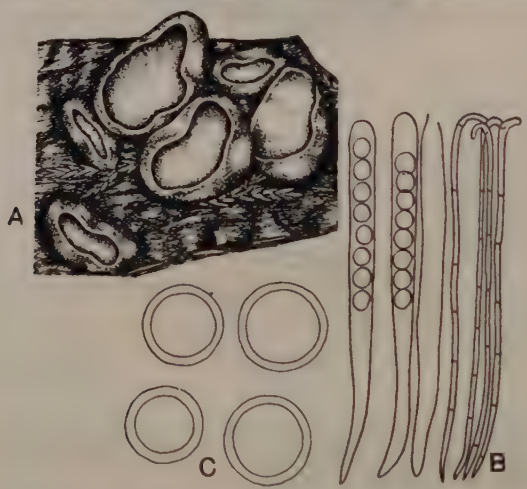
Asci 205–255 × 16–20 μ, cylindrical, apex rounded, tapering below into a stem-like base.

Ascospores 12–14 μ in diameter, 8 in number, uniseriate, hyaline to subhyaline, smooth, uniguttulate, guttule large and filling almost whole of the spore cavity.

Paraphyses 220–240 × 2 μ, pink, filiform, simple, septate, strongly curved or hooked at the top, extending beyond the asci.

Text-Fig. 2, A–C.

Collected on charcoal beds which were overgrown by mosses, Jabber Khet, Mussoorie, August 20, 1952, **154**. New record in India.



TEXT-FIG. 2. *Lamprospora carbonaria* (Fckl.) Seaver. A. Apothecia, ×10. B. Asci and paraphyses hooked at the top, ×200. C. Smooth spores with a large gutta, ×880.

This fungus undoubtedly belongs to *Lamprospora carbonaria* (Fckl.) Seaver except that its apothecia are pink and its spores are smaller for the species. All other characters are well within the range of the species.

24. *Pithya Cupressi* (Batsch) Rehm in *Rab. Krypt., Fl.*, 1[3]: 926, 1896.

Syn.: *Peziza Cupressi* Batsch, *Elench. Fung.*, **1**: 119, 1783.

Peziza cupressina Fries, *Syst. Myc.*, **2**: 135, 1822.

Pithya cupressina Fuckel, *Symb. Myc.*, 317, 1869.

Humaria cupressina Quél., *Ench. Fung.*, 289, 1886.

Helotium thujinum Peck, *Ann. Rep. N.Y. State Mus.*, **26**: 82, 1874.

Phialea cupressina Gill., *Champ. Fr. Discom.*, 107, 1882.
Lachnella Cupressi Phill., *Brit. Discom.*, 240, 1887.
Pithya thujina Sacc., *Syll. Fung.*, **8**: 210, 1889.

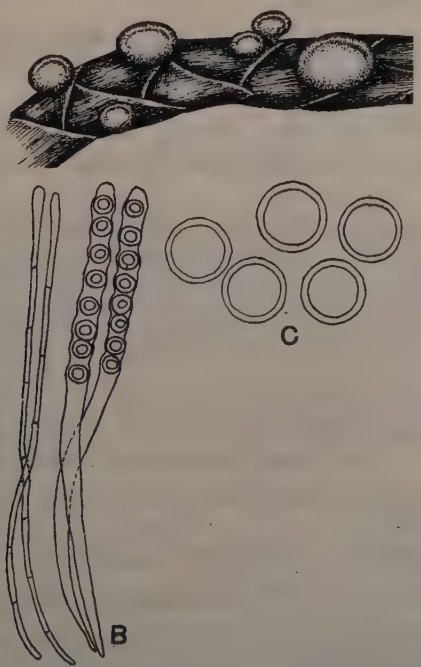
Apothecia 1–2 mm. in diameter, scattered or gregarious, sessile to shortly stipitate, at first globose, later expanding and becoming shallow cup-shaped or discoid, yellow to orange, tough; external surface lighter coloured than the hymenium, smooth: excipular cells vertically elongated giving rise (at the base of apothecia) to white mycelial threads by means of which the apothecia are attached to the substratum; margin entire; hymenium concave to plane, dotted with protruding out asci, yellow to orange; stipe distinct to indistinct, very short and thick.

Asci 150–180 × 11–12 μ, cylindrical, apex rounded, gradually tapering below into a long stem-like base.

Ascospores 9–12 μ in diameter, 8 in number, uniseriate, hyaline to subhyaline, perfectly globose, smooth, uniguttulate, guttule large and filling almost whole of the spore cavity.

Paraphyses 200–220 μ long, 2–3 μ wide at the top, filiform, slightly enlarged above, often branched below, septate.

Text-Fig. 3, A–C.



TEXT-FIG. 3. *Pithya cupressina* (Fr.) Fckl. A. Apothecia on a dead twig of *Cupressus* sp., ×5. B. Asci and paraphyses, ×200. C. Smooth uniguttulate ascospores, ×880.

Collected on dead foliage of *Cupressus* sp. Cemetry Grounds, Camel's Back Road, Mussoorie. August 11, 1952, **155**. New record in India.

This species is commonly observed on fallen twigs of *Cupressus* sp. in the Mussoorie Hills. It is marked by very small, yellow to orange, sessile to subsessile apothecia, asci tapering below into a long stem-like base, and smooth, uniguttulate ascospores.

25. *Ascobolus magnificus* Dodge, *Mycologia*, **4**: 218, 1912.

Apothecia 0·5–1·8 cm. in diameter, gregarious and congested together in masses covering several centimetres of the substratum, sessile, at first globose, later expanding and becoming shallow cup-shaped and discoid or scutellate, often becoming irregular or contorted due to mutual compression, yellow, fleshy, brittle; external surface pale yellow, lighter coloured than the hymenium, smooth: margin entire to wavy; hymenium concave to plane, yellow, later turning brown and rough due to the mature protruding asci.

Asci 150–215 × 19–20 μ, cylindrical, apex rounded to truncated, tapering below into a short stem-like base.

Ascospores 21–26 × 10–12 μ, 8 in number, irregularly uniseriate, at first hyaline, then violet, and finally brown, smooth, surrounded by a thick gelatinous sheath.

Paraphyses 260–285 × 3 μ, yellow, filiform, simple, septate, bent at the top.

Text-Fig. 4, A–C.

Collected on cow dung, Jamna Bridge, Mussoorie, August 3, 1952, **156**.

This collection (n. 156) from the Mussoorie Hills belongs to *Ascobolus magnificus* Dodge. It differs from the latter in smaller apothecia lacking pruinose external surface, smaller asci and paraphyses narrower at the top. These minor differences are considered here due to different environments. *A. magnificus* Dodge is reported on horse dung in damp chamber cultures (Seaver, 1928, p. 87) which may account for the larger dimensions.

26. *Ascobolus carbonarius* Karst (? *Fungi Fennici*, 463, 1866); *Not. Fauna Fl. Fenn.*, **11**: 202, 1870.

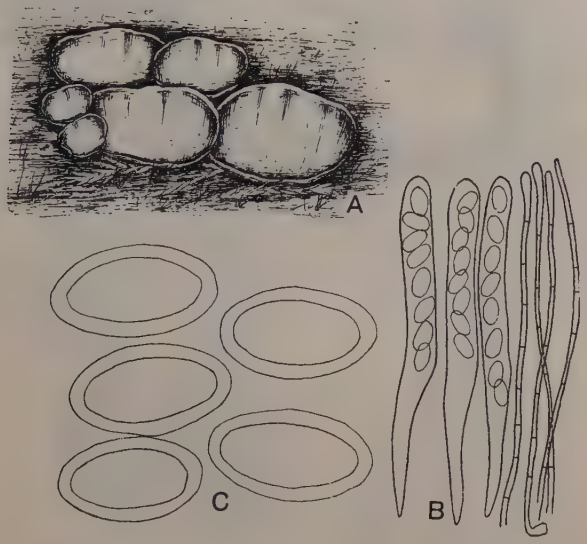
Syn.: *Ascobolus carbonicola* Boud., *Bull. Bot. Soc., Fr.* **24**: 310, 1877.

Ascobolus atrofuscus Phill. and Plow., *Grevillea*, **2**: 186, 1873.

Phœopezia Nuttallii Ellis and Ev., *N. Am. Fungi*, 2908, 1893.

Apothecia 5–6 mm. in diameter, gregarious or congested together into masses covering several centimetres of the substratum, or sometimes scattered, shallow cup-shaped to discoid or scutellate, regular or contorted due to mutual compression, brown, fleshy, smooth; external

surface brown, smooth, lighter coloured than the hymenium: margin entire; hymenium dark brown, concave to plane roughened by protruding asci.



TEXT-FIG. 4. *Ascobolus magnificus* Dodge. A. Apothecia, ×2. B. Asci and paraphyses, ×200. C. Smooth ascospores surrounded by a thick, gelatinous sheath, ×880.

Asci 180–200 × 18–25 μ, clavate, apex rounded to truncated, tapering below rather abruptly into a short to slightly long stem-like base.

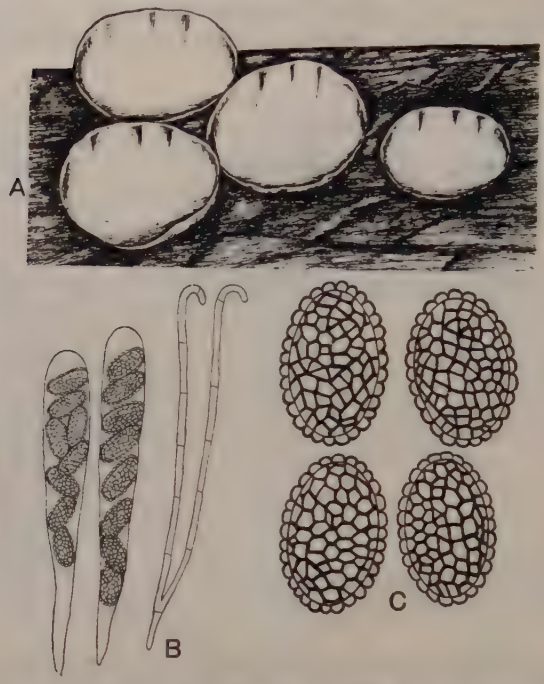
Ascospores 17–24 × 11–15 μ, 8 in number, irregularly uniseriate, at first hyaline, then violet and finally brown to dark brown, ellipsoid, rarely subglobose, at first smooth, later becoming profusely and prominently verrucose-reticulate, warts coarse and tuberculate, reticulations appearing only in fully mature dark brown spores.

Paraphyses 200–230 × 2–3 μ, brown, filiform, septate, branched at the base, usually bent at the top, not enlarged at the top.

Text-Fig. 5, A–C.

Collected on charcoal preparation beds, The Municipal Gardens, Mussoorie, July 26, 1952, **157.** New record in India.

This fungus undoubtedly belongs to *Ascobolus carbonarius* Karst. It is characterized by small, brown, apothecia found in congested masses on burnt places, asci tapering below abruptly, and ellipsoid, smooth, verrucose-reticulate ascospores.



TEXT-FIG. 5. *Ascobolus carbonarius* Karst. A. Apothecia, ×5. B. Branched paraphyses strongly curved at the top and asci ×200. C. Profusely and prominently verrucose reticulate ascospores, ×880.

27. *Aleuria aurantia* (Pers. ex Fr.) Fckl., *Symb. Myc.*, 325, 1869.

Syn.: *Peziza aurantia* Pers., *Obs. Myc.*, **2**: 76, 1797.

Elvela coccinea Schaeff., *Fung. Bavar.*, **4**: 100, 1774. *Not Elvela coccinea Scop*, 1772.

Peziza coccinea Bull., *Herb. Fr. pl.*, 474, 1789.

Scodellina aurantiaca S. F. Gray, *Nat. Arrang. Pl.*, 668, 1821.

Otidea aurantia Massee, *Brit. Fungus-Fl.*, **4**: 448, 1895.

Apothecia up to 6 cm. in diameter, gregarious or scattered, sessile, rarely shortly stipitate, at first globose, later on expanding and becoming deep cup-shaped, finally shallow cup-shaped to discoid, orange, fleshy, regular when young, becoming irregular and contorted with age or by mutual compression when growing close by, rarely cleft on one side like *Oridea*; external surface whitish, pruinose due to the presence of delicate hairs; pruinose hairs up to 435 μ long, up to 14 μ wide at the base, 5 μ wide at the top, hyaline, septate, short, simple, tapering upward; margin entire to wavy: hymenium concave, orange, marked by ridges and grooves in the centre, otherwise smooth.

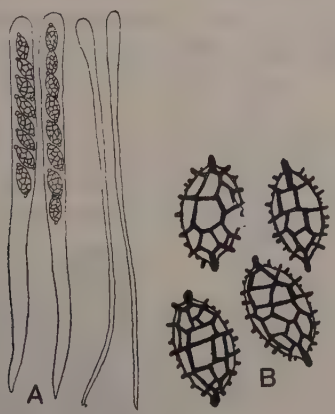
Asci 172–210 × 9–13 μ, cylindrical, apex rounded, tapering gradually into a short stem-like base.

Ascospores 15–21 μ long including the apiculus, 7–10·5 μ wide including the warts, 8 in number, uniseriate, parallel to oblique, hyaline, ellipsoid, apiculate mostly at both ends, apiculus very prominent, blunt to spiny and up to 2–5 μ long, at first smooth and 1–3 guttulate, later on becoming prominently reticulate, reticulations extending beyond the spore surface as apiculi at the ends and as warts on the rest of the surface.

Paraphyses 200–240 × 3 μ, 7–9 μ wide at the top, clavate, orange, simple, strongly and abruptly swollen at the top, filled with orange granules.

Pl. XIV, Fig. 1; Text-Fig. 6, A–B.

Collected on soil, Jabber Khet, Mussoorie, August 18, 1952, **158.** New records in India.



TEXT-FIG. 6. *Aleuria aurantia* (Pers. ex Fr.) Fckl. A. Asci and apically enlarged paraphyses, ×200. B. Prominently reticulate and apiculate ascospores, ×880.

This is a very beautiful fungus commonly observed in the Mussoorie Hills. It is easily recognized by its orange apothecia with whitish pruinose external surface, hyaline, prominently reticulate spores and orange paraphyses strongly and abruptly swollen at the top.

28. *Aleuria rutilans* (Fr.) Gill., *Champ. Fr. Discom.* 53, 1879.

Syn.: *Peziza rutilans* Fries, *Syst. Myc.*, **2**: 68, 1822.

Leucoloma rutilans Fuckel, *Symb. Myc.*, 318, 1869.

Humaria rutilans Sacc., *Syll. Fung.*, **8**: 133, 1889.

Sarcoscypha albovillosa Rehm., *Ann. Myc.*, **2**: 33, 1904.

Apothecia up to 1 cm. in diameter, solitary, occurring singly among mosses, stipitate, cupulate, at first closed, later expanding and becoming turbinate, yellow, regular, fleshy, hairy; external surface whitish, hairy; hairs 460–480 × 8 μ, hyaline, simple, unseptate, swollen at the

base, bristle-like above, apex rounded, thick-walled, rigid and erect; margin dentate, hairy; hymenium concave, yellow, smooth: stipe 1–5 × 0·5–1 mm., cylindrical, hairy, thick, solid, gradually expanding above into the apothecium.

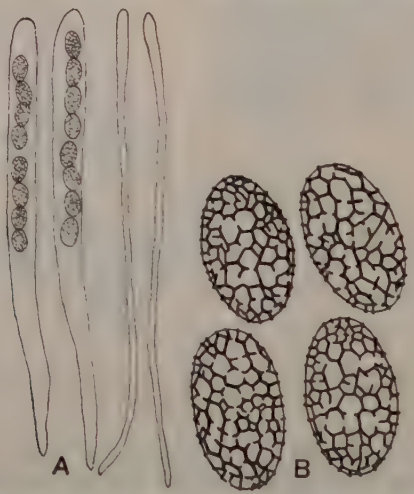
Asci 250–280 × 17–18 μ, cylindrical, apex rounded, gradually tapering below into a short stem-like base.

Ascospores 19–26 × 10–13 μ, 8 in number, uniseriate, parallel, hyaline, ellipsoid, at first smooth with 2–3 guttules, later on becoming prominently reticulated, reticulations which are often interrupted or incomplete appearing as warts on the surface, apiculi absent.

Paraphyses 215–240 × 3 μ, up to 5 μ wide at the top, yellow, filiform, simple, slightly enlarged at the top.

Pl. XIV, Fig. 2; Text-Fig. 7, A–B.

Collected on living moss (*Mnium heterophyllum*), Jabber Khet, Mussoorie, August 20, 1952, **159.** New record in India.



TEXT-FIG. 7. *Aleuria rutilans* (Fr.) Gill. A. Asci and paraphyses, ×200. B. Reticulate ascospores with incomplete reticulations, ×880.

This collection resembles *Aleuria rutilans* (Fr.) Gill. in all respects except that its hairs are unseptate. It is easily differentiated from *Aleuria aurantia* (Pers. ex Fr.) Fckl. by its stipitate but smaller apothecia, and the absence of apiculi on its spores.

29. *Cookeina colensoi* (Berk.) Seaver, *Mycologia*, **5**: 191, 1913.

Syn.: *Peziza colensoi* Berk. in Hooker's *Fl. New Zealand*, **2**: 200, 1855.

Peziza aluticolor Berk., *Proc. Linn. Soc.*, **13**: 176, 1873.

Phillipsia venezuelæ Berk. and Curt., Cooke, *Mycographia*, 120, 1876.

Geopyxis aluticolor Sacc., *Syll. Fung.*, **8**: 64, 1889.

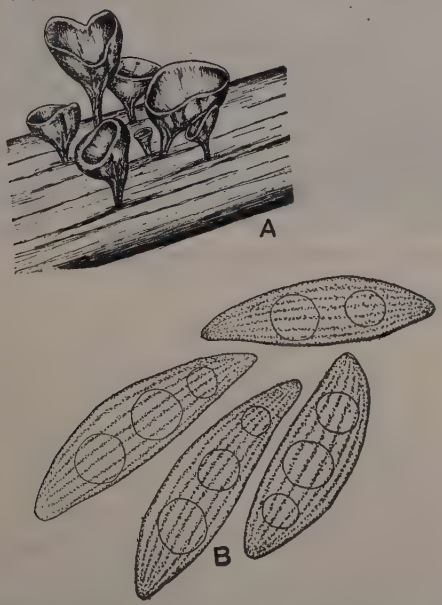
Sarcoscypha colensoi Sacc., *Syll. Fung.*, **8**: 157, 1889.

Peziza venezuelæ Massee, *J. Linn. Soc.*, **31**: 473, 1896.

Apothecia 1–2·2 cm. in diameter, gregarious, stipitate, deep cup-shaped, pink to red, fleshy-tough; external surface marked by conspicuous ridges radiating from the top of the stipe, ridges may or may not spread up to the margin, in some cases ridges covering whole of the external surface and often becoming confluent so as to appear reticulate; hymenium pink to red, smooth; margin hairy; hairs in fascicles, fascicles up to 600 μ long and up to 100 μ broad at the base, individual hairs up to 5·3 μ broad at the base, fascicles pyramidal or conical and composed of a large number of hairs, hyaline, filiform, delicate, simple, septate, gradually narrowed above, apex rounded; stipe 1–2 cm. long, 2–3 mm. wide, concolorous with the apothecium, solid, cylindrical, somewhat longitudinally corrugated.

Asci 340–370 × 13–16 μ, cylindrical, apex rounded, abruptly narrowed below into a short appendage-like base.

Ascospores 26–36 × 7–12 μ, 8 in number, uniseriate, parallel, narrowly ellipsoid, ends round to pointed, subhyaline, smooth but finely longitudinally striated, striations composed of numerous light and dark bands, 2–5 guttulate, usually 2–3 guttulate, guttules in a longitudinal row.



TEXT-FIG. 8. *Cookeina colensoi* (Berk.) Seaver. A. Stipitate and deeply cupulate apothecia, ×1. B. Narrowly ellipsoid finely striated ascospores with 2–3 guttules, ×880.

Paraphyses 300–350 × 2–3 μ, filiform, simple, septate, scarcely enlarged above.

Text-Fig. 8, A–B.

Collected on rotting wood of *Dalbergia* species, Dehra Dun, September 2, 1952, **160.** New record in India.

This species is recognized by stipitate apothecia, external surface without well-developed hairs and narrowly ellipsoid, guttulate, striated ascospores. It differs from *Cookeina sulcipes* (Berk.) Kuntze in longer and narrower spores.

Acknowledgments

The authors are deeply indebted to Miss Edith K. Cash of U.S. Dept. Agr., Beltsville, Maryland, for help in the identification of the species and valuable suggestions and Prof. P. N. Mehra for encouragement and facilities. They are also thankful to Mr. B. Khanna for making illustrations of the fructifications.

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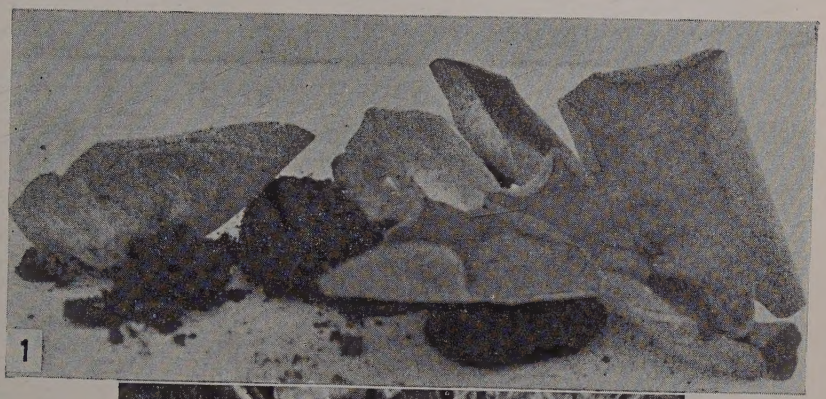
Explanation of Plate XIV

Fig. 1. *Aleuria aurantia* (Pers. ex Fr.) Fckl.

Fig. 2. *Aleuria rutilans* (Fr.) Gill.



K. S. Thind and L. R. Batra

REVIEWS

A Hand Book of Some South Indian Weeds (with illustrations). By C. Tadulingam and G. Venkatanarayana. Revised and enlarged by C. Rajasekhara Mudaliar and J. Sakharam Rao. Printed by the Superintendent, Government Press, Madras, 1955. Pp. xi + 488. 180 Plates. Price Rs. 7.

This is the second revised and enlarged edition of the book, which has been in great demand since its publication in 1932. It is a welcome addition to the all too limited number of books on Indian weeds. It contains information on 172 South Indian weeds of arable land. The scientific, English, Hindi and local names and botanical description in popular style are given together with notes on habit, habitat, range of distribution, methods of control and economic uses. All major species have been illustrated.

In this revised and enlarged edition a new chapter has been added and is devoted to latest developments in the chemical eradication of weeds; describing the more important hormone weedicides in use, their selective action in destroying weeds, and their effect on crops. The biological methods of controlling weeds attempted in South India are also indicated. In this revised edition 64 more weeds have been added of which 50 have been described in detail with illustrations, and for the remainder short descriptions have been provided. Hindi names of plants are also given in this edition along with other local names, in the hope that the book may be of use in Agricultural Colleges throughout India. A few coloured plates have also been included to make the book attractive.

The volume is handy, and the printing in general is good and the price, Rs. 7, brings it within the reach of the ordinary reader.

There is, however, one fault that the reviewer has to find with this book, and this is in connection with the nomenclature of plants adopted therein, since the book is offered as a more or less technical work. To mention but a few points: on p. 73 the authors give the name *Nasturtium indicum* DC. This is now placed under *Rorippa* and goes as *Rorippa indica* (Linn.) Hochreut.; *Gynandropsis pentaphylla* DC., p. 75 should be G. *gynandra* (Linn.) Briq., *Ionidium*, p. 81, goes to the genus *Hybanthus*, etc. In spite of these blemishes, which should be corrected in a subsequent edition, I recommend the book to students of agriculture as it fills a real need in the country.

M. B. Raizada.

The Journal of The Madras University, Vol. 27 B. Centenary Number, January, 1957. Published by the University of Madras. Price Rs. 4.

While in many fields "the newest is the best", it is not so with educational institutions, where age lends dignity and a charm of its own. It is a matter for real gratification that three of our universities are now 100 years old and celebrated recently their centenary.

The special number of the *Journal of The Madras University* includes a large number of articles by persons eminent in different branches of science. Nearly half a dozen of these should be of interest to botanists. Dr. Nils Fries describes an experiment aiming at the possibility of isolation of biochemical mutations in *Pisum sativum* by exposing seeds to X-rays. Emil Müller gives an account of three new Ascomycetes on *Spartium junceum* and Professor M. O. P. Iyengar describes the structure and life-history of *Cylindrocapsopsis indica* Gen. et Sp. Nov. Maheshwari *et al.* have reviewed the floral morphology and embryology of the Loranthoideæ. Synder, Hansen and Oswald have contributed a paper on Cultivars of *Fusarium*. Other articles of interest to biologists are the Problematics of the Phenomenon of Phenocopy by Goldschmidt; Biological Study of Mechanism of Carcinogenesis by Khanolkar and The Elementary Theory of Population Growth by J. B. S. Haldane.

In a supplement to this Number is given a resumé of the investigations carried out by the different Departments of Science of The Madras University since their inception. The account begins with the Department of Botany which was founded in 1930. The researches carried out by this Department make an impressive record. During 27 years of its existence, there have appeared a large number of papers from its laboratories and about twenty persons have taken the Doctorate Degree.

The University may be congratulated heartily for its past achievements. Those who know some of its alumni and the faculty look forward with confidence and joy to the further expansion of the activities of the different Departments in coming years to meet the growing needs of the nation for trained personnel.

A. C. JOSHI.

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